AIR FORCE HANDBOOK 10-222, Volume 7
1 September 1999

EMERGENCY AIRFIELD LIGHTING SYSTEM (EALS)

DEPARTMENT OF THE AIR FORCE

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 SEP 1999	**N/A**	**-**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Emergency Airfield Lighting System (Eals) - Air Force Handbook 10-222, Volume 7	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Secretary Of The Air Force Washington, DC**	8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**UU**	**105**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

BY ORDER OF THE SECRETARY OF THE AIR FORCE

AIR FORCE HANDBOOK 10-222, VOLUME 7
1 SEPTEMBER 1999

Operations

EMERGENCY AIRFIELD LIGHTING SYSTEM (EALS)

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Pages: 104/Distribution: F

This handbook summarizes the key steps for installing, operating, maintaining, troubleshooting, and repacking the Emergency Airfield Lighting System (EALS). It contains checklists that serve as memory joggers for civil engineer electrical and power production technicians. It augments but does not replace TO 35F5-3-17-1, *Lighting System, Airfield, Emergency A/E82U-2*. Anyone using this handbook should have hands-on experience with the EALS and have read the applicable technical orders.

Throughout this handbook you will see **NOTES** and **HINTS**. They provide supplemental information to help you understand why actions are required or how a task is performed. You will also see **WARNINGS** and **CAUTIONS**. They provide information on actions that must be performed correctly to avoid a safety problem.

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SYSTEM DESCRIPTION

Purpose and Capability. The EALS is a runway lighting system designed to be rapidly installed at contingency airfields and at other locations that need temporary airfield lighting. The system supports flying operations at night and during periods of reduced visibility. It provides runway edge lighting, approach lighting, threshold/end lighting, taxiway lighting, Precision Approach Path Indicator (PAPI) lights, Distance-To-Go (DTG) marker lighting, and obstruction lighting.

The EALS can be installed and secured on all types of surfaces (e.g., sand, frozen earth, mud, ice, asphalt, and concrete). The system can light a runway or minimum operating strip (MOS) up to 150 feet wide by 10,000 feet long. Under ideal conditions, a six-person crew can install the system on a 50-foot by 5,000-foot MOS in 2½ hours using two general purpose vehicles (e.g., ¾ ton pick-up, 1 ton, 1½ ton trucks, etc.). Civil engineers can install the EALS when wearing chemical defense ensembles or arctic clothing.

Subsystems. The EALS has three subsystems: the lighting subsystem, the power and control subsystem, and the packaging subsystem. Table 1 highlights the major elements in each subsystem.

Theory of Operation. The EALS includes two 30 kW tactical quiet generators (MEP-805A) to power to the system. One generator serves as the primary unit—the other as a standby unit—to provide 416 VAC input power to a 20 kW constant current regulator. Either generator can serve as the primary unit. **NOTE:** These generators have one "non-standard" feature, a remote start kit that allows you to operate the generators from the system control panel.

Table 1. EALS Subsystems.

LIGHTING SUBSYSTEM	POWER AND CONTROL SUBSYSTEM	PACKAGING SUBSYSTEM
Edge lighting	Generators	Trailers
Approach lighting	Regulators	Cable reels
Threshold/end lighting	Control Panels	Containers
PAPI systems	Cabling	Tools and spares
Taxiway lighting	Cable protection	
DTG (and aircraft arresting system) marker lighting		
Obstruction marker lighting		

Except for the battery powered obstruction lights, all EALS lighting equipment is connected in a single primary series-circuit. The regulator provides a constant current to that circuit. Control of the power delivered to and from the regulator is normally accomplished at the EALS control panel, but can also be done at the regulator panel. Except for the approach strobes, a single switch controls all the lights on the series circuit.

If properly connected, the EALS primary control panel automatically transfers the load from the primary generator to the standby unit if the primary unit fails. The load can be manually transferred from one generator to the other at the primary control panel. The generators can also be started and stopped from the primary control panel.

The control panel has a rotary switch with three settings to control the intensity of the runway lights. The nominal regulator output at each setting is 4.8 amps (low), 5.5 amps (medium), and 6.6 amps (high). The switch controls the intensity of the edge lights, approach lights, threshold/end lights, taxiway lights, and DTG (and aircraft arresting system) marker lights. **NOTE:** Light intensity can also be controlled from a rotary switch on the regulator panel.

The series lighting circuit powers the approach strobes located at each end of the runway. An approach strobe segment consists of one strobe master unit and two strobe slave units. The strobe units flash in sequence from the outermost to the innermost unit at one end of the runway or the other. A three position rotary switch on the control panel selects the appropriate approach strobe segment. When the series circuit is energized, the approach strobes can be turned on or off independent of the runway lights.

There are spares for every component in the EALS. This includes the regulator and the control panel. The backup regulator and backup control panel do not have the full capabilities of the primary units. **Only one generator can be physically connected to the backup control panel**.

Packaging. The air transportable EALS is packed on six trailers that fit within the space of three aircraft pallet positions. The placement of the items on cable reels and in storage cabinets provides for easy access to the system components during installation. **NOTE:** There are enough components on four of the trailers (#2, #3, #4, and #5) to install a lighting system on a 50-foot by 5,000-foot MOS.

Figure 1. EALS Trailers.

TRAILER #1

TRAILER #2

TRAILER #3

TRAILER #4

TRAILER #5

TRAILER #6

Table 2. Use of EALS Trailers.

TRAILER	PRIMARY USE
# 1	Contains primary control panel and regulator (with connections for two generators). Also contains taxiway lights and reflectors, obstruction lights, and a spare PAPI and strobe master unit.
# 2	Contains fixtures and cables for lighting one end and one edge of a runway/MOS.
# 3	Contains fixtures and cables for lighting opposite end and edge of a runway/MOS.
# 4	Contains backup control panel and regulator (with connection for one generator). Also contains strobe slave units and extra cables for edge and end lighting plus generator power and control cables and ground cables.
# 5	MEP-805 generator serves as primary or backup power source for the EALS.
# 6	MEP-805 generator serves as primary or backup power source for the EALS.
Attachment 1 lists the contents of each trailer.	

Limitations. The EALS is designed for temporary use as a contingency lighting system. It is not designed for permanent use.

It is not designed to support instrument flight rules (IFR) operations, **nor is it designed for use when meteorological visibility is less than four statute miles**.

While rated at 20 kW, the EALS regulator cores are factory-adjusted for a maximum output of 13 kW. This limits the output voltage of the regulator to below 2000 VAC, which allows the use of smaller diameter cables (thinner insulation can be used). This, in turn, reduces the overall volume of a packaged EALS and minimizes the number of aircraft pallet positions needed to move the complete system. However, there is a penalty for the reduced regulator output. The regulator cannot power the system to full intensity when the series circuit is fully loaded (or nearly so). This limitation occurs when all or most of the lights are connected to the series circuit in a complete

or near complete 150-foot by 10,000-foot layout. In that situation, even though the intensity selector switch is set on high, the maximum output current will be limited to less than the nominal 6.6 amps, and the system lights will not illuminate to full intensity.

While the regulators can be adjusted to operate from a 208 VAC power source, the automatic transfer switch on the primary control panel must have 416 volts. The secondary control panel does not have this limitation and can work on 208 volts.

Essential Technical Orders. In addition to TO 35F5-3-17-1, *Lighting System, Airfield, Emergency A/E82U-2*, be sure to have a copy of TO 35C2-3-446-11, *Generator Set, Diesel Engine Driven, Skid Mounted, 30 kW, 3 phase, 4 wire, 120/208 and 240/416 volts, Operator and Organizational Maintenance Manual*.

Commonly Used Terms. The following terms are used in the rules and procedures in this handbook. Also see Figure 2.

Runway/MOS	This is the paved surface used by aircraft to takeoff and land. Since a pilot can land on each surface from two directions (180° apart), each paved surface is really two runways. Runway edge lights and the threshold/end lights outline the lateral and longitudinal limits of the usable surface of the runway/MOS. In this handbook, this combined term indicates that the EALS can be set up on either an in-place runway or on a smaller minimum operating strip (MOS).
Inboard or Outboard	Describes the placement of an EALS component relative to the runway/MOS (or taxiway). View inboard as closer to and outboard as farther from the paved surface.

Runway threshold/end	The threshold is the beginning portion of the usable pavement as viewed by the approaching pilot, while the runway end is the last portion of the usable runway/MOS available to a pilot. The threshold is marked by green lights and the runway end by red lights. When the threshold of a runway/MOS is co-located with the end of the opposite runway/MOS, the threshold/end lights have a split lens with green on one side and red on the other.
END	This term refers to the approach threshold/departure end of a runway/MOS where an EALS team begins installing the system. END A refers to the threshold/end where TEAM A begins. END B is the opposite threshold/end where TEAM B begins.
EDGE	This term refers to one of the long sides of the runway/MOS. EDGE A is the side of the runway/MOS in the clockwise direction from end A. EDGE B is the other side.
Unidirectional runway/MOS	Unidirectional describes a condition where, for whatever reason, aircraft takeoff and land on the runway/MOS in only one direction. If that condition is not temporary, approach lights and strobes are required only at the approach end, and distance-to-go lights are placed only on the right side of the runway/MOS.
Bi-directional runway/MOS	The runway/MOS can support aircraft operations in both directions.

Runway/ MOS designation	This is a two-digit number that designates the magnetic heading of a runway/MOS. As viewed from an inbound aircraft, the heading of the runway/MOS centerline is measured clockwise from magnetic north. The compass reading is rounded to the nearest 10 degrees, and the last digit (a zero) is dropped. For example, when the magnetic heading of a runway/ MOS is 068°, the runway designation is 07 (round 068 to 070 and drop the last digit). When viewed from the opposite direction, the pavement is considered a separate runway/MOS, and its designation is 25 (180° in the opposite direction). The designations are normally painted on the ends of runways, but not on minimum operating strips. See Figure 3.
Runway Reference Point (RRP)	The RRP is the point on the runway/MOS centerline where the visual glide path used for the PAPI system intersects the runway/MOS.

SYSTEM LAYOUT

Placement Rules. The rules for placing and spacing the EALS lighting elements generally conform to the standard Federal Aviation Administration (FAA) and Air Force criteria (see AFMAN 32-1187(I), *Design Standards for Visual Air Navigation Facilities*). Because it is written for emergency conditions, the EALS technical order does contain allowable deviations from those criteria. In this handbook, the deviations allowed for emergency conditions are noted following the standard placement rules. **NOTE:** When time and conditions permit, use the standard placement rules.

Edge Lights. The system contains 116 fixtures (includes 4 spares) and 113 isolation transformers (IL) (includes 1 spare), which is enough for a 10,000-foot long runway/MOS plus 7 approach lights at each end. **NOTE:** The same 45W isolation transformers are used with the taxiway lights and distance-to-go marker lights.

Fixture uses clear glass lens, 45W lamp, and 45W IL

Placement Rules (also see Figure 4)

* Place fixtures in line, no more than 10 feet from the edge of runway/MOS surface. Place inside of orange edge markers. Put isolation transformer outboard of fixture.
* Space fixtures evenly along both edges of runway/MOS, no more than 200 feet apart. Keep fixtures on both edges directly across from each other.
* Don't place fixtures in the intersections with taxiways or in the tape sweep area of aircraft arresting systems (see Attachment 2).

Allowable Deviation in Emergency Conditions

* Spacing of fixtures may be up to 300 feet apart. **NOTE:** Spacing greater than 200 feet requires 2 runway cable segments between fixtures.

Threshold/End Lights. System contains 33 fixtures and 33 isolation transformers (IL) (includes 1 spare each), enough for a 150-foot wide runway/MOS. **NOTE:** Fixture bases are interchangeable with those used for edge, approach, and taxiway lights. Only the lens color and lamp wattage varies.

Fixture uses split red / green glass lens, 120W lamp, and 100W IL

Placement Rules (also see Figure 5)

* Place fixtures in line across each end of runway/MOS. Outboard lights must be in line with edge lights.
* Beginning at the outboard light on each side, space fixtures approximately 10 feet apart with green half of lens facing out toward the approach lights. **NOTE:** Due to the limited number of threshold/end light fixtures, you will have up to a 30-foot space between the middle two lights when the edge lights are placed 10 feet from the pavement on a 150-foot wide runway/MOS. In that situation, you can eliminate the center gap by increasing the spacing between the threshold lights from 10 feet to approximately 11.3 feet.
* Place fixtures no more than 10 feet from the end of runway/MOS. Put isolation transformer inboard of fixture.

Allowable Deviations in Emergency Conditions

* When the width of the runway/MOS is greater than 90 feet, you can limit the required number of lights to 10. Place in two groups of 5 with the outermost lights in line with the runway lights.
* Place fixtures no more than 5 feet from the end of runway/MOS.

Approach Lights. Same fixture and isolation transformer as the edge lights.

Fixture uses clear glass lens, 45W lamp, and 45W IL

Placement Rules (also see Figure 6)

* Place every 200 feet along outboard extension of runway/MOS centerline.
* At the 1000-foot approach "T", space the lights in line and l0 feet apart. Position fixtures 3 to 10 feet in front of approach strobe cabinet.

Approach Strobes. System contains 3 master strobe units (includes 1 spare), 4 slave units, and 3 series circuit adapters (SCAs) (includes 1 spare). This provides a strobe set at each end of the runway/MOS. **NOTE:** PAPIs use identical SCAs.

Placement Rules (also see Figure 6)

* Place master strobe and SCA at 1200-foot point along outboard extension of runway/MOS centerline.
* Place a slave unit at the 1000- and at the 1400-foot points on the extended runway/MOS centerline.

PAPI Lights. System contains two PAPI units plus a series circuit adapter (SCA) for each end of the runway/MOS plus a spare PAPI unit.

Placement Rules (also see Figure 7)

* Place units on left side of runway/MOS (as viewed by the pilot approaching the threshold). Attachment 3 contains instructions for determining the correct distance from the threshold to the PAPI location.
* Place units no closer than 50 feet to a runway, taxiway, or apron. Don't place other lights so close to the PAPI that those lights confuse the pilot.
* Position inboard unit 50-60 feet from edge of runway/MOS. Position outboard unit 20-30 feet from inboard unit. Place the face of both units on a line that is perpendicular to the centerline of the runway/MOS, and aim units out toward approach end.
* Peacetime mounting height tolerances: the beam centers of both units shall be within 1 inch of a horizontal plane. That plane shall be within 1 foot of the elevation of the runway at the runway reference point (RRP).

Allowable Deviations in Emergency Conditions

* Elevation difference between units (mounting height tolerance of beam centers) must be within 12 inches.
* Elevation difference between the inboard unit (beam center) and the RRP (crown of the runway/MOS perpendicular to the units) can exceed 1 foot, but you must adjust the PAPI location to account for that difference (see Attachment 3).

Distance-To-Go (DTG) Marker Lights. System contains 10 fixtures and isolation transformers (IL).

Fixture uses 45W PAR lamp and 45W IL

Placement Rules (also see Figure 8)

* Place every 1000 feet to illuminate the diamond shaped DTG markers. Start 1000 feet from the end of the runway/MOS and proceed to the 5000-foot marker.
* Sign is located on right side of runway as viewed by pilot and 50–75 feet from edge of runway/MOS on no more than half the width of the runway/ MOS, whichever is less.
* Keep away from PAPI to reduce pilot confusion.

Allowable Deviation in Emergency Conditions

* Following an attack, Engineering technicians may place DTG markers only 25 feet from the edge of the runway/MOS to minimize risk to UXO.

Aircraft Arresting System Marker Lights. This is the same fixture and isolation transformer as the DTG marker light. EALS has no fixtures designated for this purpose. Must take lights away from the DTG markers in order to illuminate the AAS markers (take first from 5000-foot markers.)

Fixture uses 45W PAR lamp and 45W IL

Placement Rules (also see Figure 8)

* Position fixture to illuminate the diamond shaped aircraft arresting system sign. Sign is located on right side of runway as viewed by pilot, 50-75 feet from edge of runway/MOS, outboard of the aircraft arresting system, and in line with the arresting system cable.
* Keep fixtures away from PAPIs to reduce pilot confusion.

Allowable Deviation in Emergency Conditions

* Following an attack, Engineering technicians may place arresting system markers only 35 feet from the edge of the runway/MOS.

Taxiway Lights/Reflectors. System contains 40 fixtures and isolation transformers (IL) and 250 reflectors.

Uses blue glass lens, 30W lamp, and 45W IL

Placement Rules (also see Figure 9)

* Place fixtures no more than 10 feet from edge of taxiway.
* Space fixtures 50 feet apart in straight sections and 25 feet apart in curves.
* Place taxiway exit lights (double lights) at the beginning of the curve into a taxiway. Place inboard light 2 feet outside of the line of edge lights. (Be sure inboard light is not in line with edge lights.) Place second light 5 feet outboard of the first light and perpendicular to the centerline of the runway/MOS.
* Use reflectors away from the runway/MOS to free up lights for other taxiways. There is no set distance away from runway/MOS for this transition.

Allowable Deviations in Emergency Conditions

* The spacing between lights cannot exceed 220 feet in straight sections or 100 feet in curved sections of a taxiway.

Obstruction Lights. System contains 10 battery-powered blinking red lights.

Placement Rules

* Place at 10 most significant obstructions. **NOTE:** You don't have to use all 10 lights if there are not that many obstructions.

Regulators/Generators. System contains a primary and a backup regulator and two MEP-805A generators.

Placement Rules (also see Figure 10)

* Can place regulator at any place in the circuit. Pick a location that provides easy access for servicing the generators.
* Position units at least 60 feet from the runway/ MOS, but 200-600 feet is better.
* Generators can be placed at varying distances from the regulator so long as the total length of the power cable and control cable used to connect the generators with the regulator does not exceed 1000 feet.
* Place auxiliary fuel supply within 25 feet of generators.

PREINSTALLATION

Required Information. Before beginning the EALS installation, the team must get information on the runway/MOS location, taxiway locations, direction of aircraft takeoffs and landings, approach slope/PAPI aiming angle, and light systems to be set up. **CHECKLIST 1** highlights that information.

Pre Employment Checks. CHECKLIST 2 outlines equipment checks that should be made before the system is used.

Pre-Marking of Light Locations. The procedures in this handbook are based on the assumption that Engineering technicians mark the location of the runway/MOS, the taxiways, the approach lights, strobes, PAPI, DTG markers, and the aircraft arresting systems before the EALS is installed. If the locations are not marked, install the lights using the placement criteria in this handbook. Attachment 3 contains instructions for determining the correct distance from the threshold to the PAPI location.

INSTALLATION

Installation Team. The EALS can easily be set up by six people organized in two teams, each team with a general-purpose vehicle. For installing the runway/MOS lighting, each team consists of three people, one of which is identified as the "TAG". During installation, two team members lay the series circuit cable and place the equipment on the ground, while the TAG follows on foot connecting the components to the primary series circuit.

The two teams start at opposite ends of the runway/MOS and perform identical tasks, with two exceptions. TEAM A installs all PAPI lighting, while TEAM B sets up the regulator and generators. The “A” and “B” designation is arbitrary and used only as a way to distinguish between the two teams, the TAGs, and the end or side of the runway/MOS that the teams are working. (**NOTE:** In this handbook, TEAM A installs the approach lighting for a unidirectional runway/MOS.)

When the runway/MOS installation is complete, one of the teams borrows a person from the other team to install the taxiway lighting while the remaining two people place the obstruction lights.

Safety Summary. CHECKLIST 3 highlights safety practices the installation team should follow.

Equipment Distribution for the Runway/MOS Installation. Trailer #2 (or #3) contains most of the lighting equipment and tools needed to install the EALS on one end and one side of a runway/MOS. When directed to install the EALS, TEAM A hooks up to trailer #2 and TEAM B tows trailer #3. Before moving, the teams should reposition the strobe master units and the PAPIs from the top of trailers 2 and 3 to the beds of the tow vehicles. Each team should draw needed additional items from the other trailers, as outlined in **CHECKLIST 4** and **CHECKLIST 5**, and load those items in the back of the team's vehicle.

Runway/MOS Lighting Installation Procedures. CHECKLIST 6 summarizes the steps for installing the EALS to include the edge, threshold, approach, strobes, and DTG marker lights.

For the safety of the pilot and aircraft, the PAPI must be installed correctly. **CHECKLIST 7** summarizes the installation instructions.

Unless specifically noted, the procedures in **CHECKLIST 6** applies to both TEAM A and TEAM B. The checklist also specifies the actions performed by each team's TAG. **NOTE:** The TAG can stay with the team to help unwind the cable from the reel and place the light fixtures. In that case, the team connects the transformers and light fixtures to the series circuit and positions those items as the cable is laid.

These procedures assume the trailers are parked near each other in a convenient operating location, such as near the regulator/control panel location. However, trailers may also be parked in dispersed and protected locations. Consequently, when directed to a trailer, the instructions mean to go wherever it is located.

NOTE: In these procedures, the term "**place**" is an action that means to put components of the EALS at or near the location they will be used, but not to connect them. "**Install**" means to both place and connect the components.

Cable Laying. Be sure to control the pay out of the cable from a cable reel. Dispensing the cable too quickly can create a backlash (rats nest).

Also, as the cable reel turns, some cables may loosen on the reel. Should a cable terminal start hitting anything as the reel rotates, immediately stop the vehicle and re-secure the loose or loosened cable end. Any of these conditions can damage the cable and/or the reel.

Don't lay two cables with different diameters at the same time. Because different diameter cables come off the reel at different speeds, you will either create a backlash (rats nest) with the smaller diameter cable or will drag the larger diameter cable along the ground.

The 125-ft and the 1000-ft ground wires are placed in the EALS package to give you maximum placement flexibility during system installation. But those wires are likely to be longer than you need. You can cut those wires to size, but be sure to replace them with full length wires when you repackage the system.

Taxiway/Obstruction Lighting Installation Procedures. CHECKLIST 8 summarizes the steps for installing the taxiway lights and obstruction lights. Repeat this process for each taxiway that intersects with the runway/MOS. These procedures assume the location of the taxiways or taxi paths are marked before the lights are installed.

A four-person team (usually TEAM A plus one from TEAM B) installs the taxiway lighting by first placing the fixtures, isolation transformers, and cable and then connecting the components together and into the primary series circuit. Once the initial lights, transformers, and cable are laid, one or two people can follow the other team members to position the lights and make the connections. Independently, a two-person team (TEAM B) places the obstruction lights.

Regulator/Generator Installation. CHECKLIST 9 summarizes the steps for installing the EALS regulator/control panel and the generators.

Generator placement is limited by the cables that connect the generators to the regulator. The EALS contains sufficient generator power cables and control cables to place one generator up to 1000 feet away from the regulator.

Protect the generator control cables. They are always needed—even when you control light intensity from the regulator panel versus the control panel. If the generator control cable is damaged or disconnected while the generator is running, the generator will shut down. When possible, mark and protect control cables so people will not drive over them. Replace or repair defective control cables.

When two generators are installed, one is usually set up within 20 feet of the regulator, while the second can be placed up to 1000 feet away. These distances are not mandatory. The two generators can be placed at any distance

from the regulator so long as the total length of the generator power and control cables used does not exceed 1000 feet. **NOTE:** When both generators are placed more than 20 feet from the regulator, you will need a longer ground cable for one of the generators. You have three options: swap a 125-ft ground wire for a 25-ft wire; get a wire from base supplies, or cut the 1000-foot ground cable into smaller lengths.

The procedures in the EALS technical order call for laying a ground wire from each generator to the common ground at the regulator. While grounding the generator, this also creates an electrical bond with the regulator and control panel. Rather than running this wire long distances, you can establish a separate ground at the generator. Just be aware, that under some circumstances, the lack of an electrical bond may cause the regulator to malfunction.

Generator Set Up. To operate the EALS from the control panel, the generators must be properly configured. **CHECKLIST 10** covers those steps.

If you must use another MEP-805A that does not have a remote start kit, you can cannibalize a remote start kit and blackout box from one of the EALS generators. The system TO contains installation instructions.

OPERATIONS

System Operations. CHECKLIST 12 summarizes the procedures for activating and operating the system from the primary control panel on trailer #1. **CHECKLIST 13** covers the procedures for using the backup control panel on trailer #4.

Manual Load Transfer. CHECKLIST 14 highlights the steps for manually transferring the load from one generator to the other using the primary control panel on trailer #1.

System Blackout. The EALS has multiple capabilities to quickly drop power to the lighting circuit if the military situation dictates the need to blackout the lights. **CHECKLIST 15** covers those steps.

Normal and Emergency Shutdown Procedures. CHECKLIST 16 addresses normal shutdown procedures for the system, and **CHECKLIST 17** covers the emergency shutdown options.

Operations Under Adverse Conditions. In extreme heat, keep the ventilation screen under the regulator free of obstructions.

Heat softens the rubber housing on runway cable connections. Hold the connectors when disconnecting cables. Reposition any pins or plugs that come loose or that slip further into the connector (Figure 11).

See the generator technical order for instructions on operating the generators in extreme cold or heat or in dusty, sandy, rainy, humid, salt water, and high altitude conditions.

TROUBLESHOOTING AND MAINTENANCE

Post Installation Actions. After the EALS is installed and operating, there are a few tasks that should be taken as time permits. See **CHECKLIST 18**.

Circuit Troubleshooting. CHECKLIST 19 provides instructions on finding and isolating an open-circuit condition in the primary series circuit. **CHECKLIST 20** summarizes the steps for finding a short-to-ground condition in the series circuit.

Equipment Troubleshooting. CHECKLIST 21 provides a checklist for on-equipment troubleshooting. **CHECKLIST 22** summarizes the troubleshooting steps for the strobe slave units, and **CHECKLIST 23** for the strobe master units. **CHECKLIST 24** lists the troubleshooting steps for the PAPI units. **CHECKLIST 25** covers control panel troubleshooting, and **CHECKLIST 26** summarizes the troubleshooting steps for the regulator.

Maintenance. Because maintenance actions are not usually time-sensitive, they are not repeated in this handbook. For detailed instructions, use the system technical order.

REPACKING

System Pickup. Picking up the system is easily done by reversing the system layout procedures. If time permits, it is a more efficient use of time to clean the system, perform deferred maintenance, and prepare the system for long term storage during the repack process. System pickup is performed more easily when all members on each team work together.

Some Cautions. Be sure to wind the cables tightly on the reels and secure the cable ends. Remember that the male ends of runway cable segments and generator control cable go onto the reel first. The female ends of the PAPI cable, strobe cable, and generator power cable go on first. The rewind instructions are stenciled on the end of the trailers for all cables (Figure 12). Don't forget to remove the ground rods at the regulator, generators, strobe masters, and PAPI units.

System Repackaging. Be sure to repair or replace damaged components before placing the system in long term storage. Also be sure that all components and storage cabinets are dry.

CHECKLISTS

CHECKLIST 1 - REQUIRED INFORMATION FOR SYSTEM INSTALLATION	
__	Determine location of runway/MOS. Length: _____ ft Width: _____ft
__	Determine which end of runway is the 1-18 end and the 19-36 end.
__	Find out which lighting sub-systems must be installed __ Edge lights __ Approach strobes 01-18 end: _____ 19-36 end: _____ __ Approach lights 01-18 end: _____ 19-36 end: _____ __ Threshold lights 01-18 end: _____ 19-36 end: _____ __ PAPI lights 01-18 end: _____ 19-36 end: _____ Approach slope angle/ PAPI aiming angle: 01-18 end: _____° 19-36 end: _____° Distance from threshold: 01-18 end: _____ ft 19-36 end: _____ ft __ Taxiway lights at taxiways: _____ / _____ / _____ __ DTG marker lights __ Aircraft arresting system marker lights __ Obstruction lights
__	Confirm that the light locations are to be premarked. Coordinate with marking team. Determine how they plan to mark the location of the runway/ MOS threshold, edges, centerline, approach zone centerline, aircraft arresting systems, taxiways, DTG markers, PAPI lights, and obstruction lights.
__	Coordinate EALS setup with MAAS installation team. Determine if aircraft arresting system is ___ unidirectional / ___ bidirectional. Determine approximate distance from MAAS that the tape would hit edge lights and runway cable (light free zone): _____ ft (see Attachment 2).
__	Determine approximate set up location for EALS regulator and generators.
__	Coordinate EALS installation and timing with crater repair operations. Don't install EALS components in locations that conflict with repair operations including debris removal.

CHECKLIST 2 - PREEMPLOYMENT EQUIPMENT CHECKS

__ Inspect and service generators per TO 35C2-3-446-11

	Trailer #5	Trailer #6
Visual inspection for leaks, loose cables, and damage	_____	_____
Fuel level	_____	_____
Oil level	_____	_____
Engine coolant level	_____	_____
Battery level and charge	_____	_____
Belts	_____	_____
Tire pressure (65 psi)	_____	_____
Hand brake	_____	_____

__ Check trailers #1 - #4

	# 1	# 2	# 3	# 4
Tire pressure (65 psi)	_____	_____	_____	_____
Hand brake	_____	_____	_____	_____
Inspect for damage	_____	_____	_____	_____
Mounted equipment secured	_____	_____	_____	_____
Inventory trailers	_____	_____	_____	_____

__ Check cable reels

	Trailer #2	Trailer #3	Trailer #4
Rewind OK	_____	_____	_____
Brake OK	_____	_____	_____
Freewheels OK	_____	_____	_____
Cable secured on reel OK	_____	_____	_____

CHECKLIST 3 - SAFETY SUMMARY
__ Remove all rings, watches, and metal-framed glasses.
__ Wear gloves and ear plugs as necessary.
__ Use only general purpose vehicles to tow trailers. Pintle hook height should not exceed 18 inches from the ground. (When the hook is higher, the extra height creates enough torque to bend or snap the tow bar when making turns.) Be sure the tail gate on the tow vehicle is up and secure before moving.
__ Trailers are top heavy. Do not exceed 25 mph on paved surfaces or 5 mph on curves. Stay on paved surfaces when at all possible. On unpaved surfaces, don't exceed 5 mph. When towing more than one trailer, reduce speed and allow extra stopping distance when braking. Don't tow more than three trailers.
__ Ensure trailer parking brake is engaged before performing any operation on or around the trailer. Always disengage brake before moving a trailer.
__ Ensure people are clear of lighting components and cables before energizing a circuit and during operation of the EALS.
__ Don't work on an energized circuit. Shut off generators before working on a circuit and disconnect runway cables from regulator output terminals.
__ Don't remove any RAC drawer or carry any SCA alone.
__ Discharge both capacitors before working inside a strobe unit.
__ Don't dispense cable from reel too quickly. Cable ends can fly off reel. Reel operator should wear gloves.
__ Be certain PAPI approach lights are installed in the correct locations and the approach angles are properly set.
__ Before operating the system, be sure the generator, regulator, and strobe are properly grounded.
__ Don't look directly into an operating strobe.
__ Don't use 45W isolation transformers with threshold/end lights.
__ Be sure power and control cables for each generator are connected to proper terminals on the control panel.
__ Pick up any loose cable protector pins to eliminate FOD potential.

CHECKLIST 4 – TEAM A: REQUIRED ADDITIONAL ITEMS	
ITEM	**GET IT FROM**
__ 1-5 Isolation transformers (45W). (Only need if runway/MOS is longer than 9000 feet.)	Trailer 1 - RAC
__ 2 Strobe slave units	Trailer 4 - on top
__ 7-19 runway cables (10-ft)	Trailer 4 - cable reel
__ 4 Ground rod sections plus 1 driver/rod	Trailer 4 - spare tire box
__ 1 Ground wire (25-ft)	Trailer 4 - cable reel
__ 1 Tool kit	Trailer 4 - UTS
__ 1 SCA	Trailer 5 - UTS
NOTE: The following additional items are required only when PAPIs are to be installed on both ends of the runway/MOS.	
__ 2 PAPI units	Trailer 3 - on top
__ 1 PAPI power cable	Trailer 3- cable reel
__ 2 Ground rod sections	Trailer 4 - spare tire box
__ 1 Ground wire (25-ft)	Trailer 4 - cable reel
__ 1 SCA	Trailer 5 - UTS

CHECKLIST 5 – TEAM B: REQUIRED ADDITIONAL ITEMS	
ITEM	**GET IT FROM**
__ 1 Runway cable adapter, male/male	Trailer 1 – RAC*
__ 1-5 Isolation transformers (45W). (Only need if runway/MOS is longer than 9000 feet.)	Trailer 1 – RAC
__ 1 Generator unit power cable (pigtail)	Trailer 1 or 2 – RAC
__ 1 Regulator power cable (6-ft)	Trailer 1 or 2 – RAC
__ 1 Regulator control cable (6-ft)	Trailer 1 or 2 – RAC
__ 5-19 runway circuit cables (10-ft)	Trailer 4 - cable reel**
__ 1 Generator power cable (25-ft)	Trailer 4 - cable reel**
__ 1 Generator power cable (250-ft)	Trailer 4 - cable reel**
__ 3 Ground wires (25-ft)	Trailer 4 - cable reel**
__ 1 Ground wire (1000-ft)	Trailer 4 - cable reel**
__ 3 Ground rod sections plus one driver/rod	Trailer 4 - spare tire box
__ 1 Generator control cable (25-ft)	Trailer 4 - cable reel**
__ 1 Generator control cable (250-ft)	Trailer 4 - cable reel**
__ 1 Tool kit	Trailer 6 – UTS
* Rather than load cable adapter in back of tow vehicle, it can stay in trailer RAC until needed (if trailer #1 regulator is used, otherwise load it in vehicle). ** If trailer #4 is used to lay cables, cables can be left on the reel until needed.	
NOTE: The following additional items are required only when approach lighting and strobes are to be installed on both ends of the runway/MOS.	
__ 2 Strobe slave units	Trailer 4 - on top
__ 2 Ground rod sections	Trailer 4 - spare tire box

CHECKLIST 6 - RUNWAY/MOS LIGHTING INSTALLATION
__ 1. Inspect and service equipment if not done earlier. See **CHECKLIST 2**.
__ 2. Get EALS installation details/information. See **CHECKLIST 1**.
__ 3. Remove, wrap, and store tarps. Tow trailers to a convenient operating location, if they are not already in position.
__ 4. Reposition strobe master units and PAPI units from the trailers to the beds of the tow vehicles. (To create more room in tow vehicle, unpack strobes/PAPIs from containers. Either reload the containers on trailers or store containers in a safe place.) If desired, unload/unpack strobe slave units also. __ Get additional items as listed in **CHECKLIST 4 (or 5)**.
__ 5. Latch RAC door open. Disengage brake. Connect trailer #2 (or #3) to vehicle. Secure all straps.
__ 6. Drive to threshold of runway/MOS. **NOTE:** If crater repair operations have not been completed, delay installation of any EALS components that would likely be damaged by those activities. **TEAM B:** If approach lights and strobes are not to be installed, skip to step 13.
__ 7. Lay runway cable (200' segments) along extended runway/MOS centerline from the threshold to the center strobe location (1,200 feet from the threshold). **CAUTION:** Control pay out of cable from the reel. Keep other cables and cable ends secured tightly to the reel.
__ 8. At the strobe master unit location (center strobe - see Figure 6), begin installing strobes. __ Unload strobe master, 2 strobe slaves, SCA, and 2 strobe SCA cables. __ Get 2 ground rod segments (3 ft), 2 ground rod couplings, 2 ground lugs, 2 ground cables (125-ft), and the ground rod driver. **NOTE:** Can swap a 25-ft ground wire for a 125-ft cable, if desired. __ Get tools (screwdriver, adjustable wrench, and the shorting stick). __ Unpack strobe master and slave units, if not already done. __ Drive ground rod at least 5 feet into the ground and connect both ground cables to it. Connect other ends of ground cables to the SCA and to the cabinet of strobe master.
CHECKLIST 6 continued on next page

CHECKLIST 6 - RUNWAY/MOS LIGHTING INSTALLATION
Step 8 continued: __ Connect shorting stick to strobe master cabinet and short C101 and C102 capacitors in all three units (Figure 13). __ Install flash tubes in all three strobe cabinets. Align key on tube with slot in socket. Put packing materials inside cabinets. **CAUTION:** Don't touch tubes with bare hands. Use packing material. __ Set ON-OFF switches (S401) to ON (Figure 14). __ On strobe master, set REMOTE-OFF-ON switch (S301) to REMOTE, and set strobe segment selector switch (S302) to correspond with the proper runway/MOS end: ____ 1-18 or ____ 19-36 (Figure 15). __ Reload strobe slave units on tow vehicle. __ Unwind and lay a 200-ft strobe cable from strobe master to the position of the inboard strobe slave unit. **NOTE:** Make sure male end of strobe cable stays at strobe master.
TEAM proceeds to step 9. TAG begins separate activities. __ **TAG:** Position the strobe master unit. Level unit with leveling feet and face window away from the runway/MOS. __ **TAG:** Place the SCA next to the strobe master, and connect the SCA's primary leads at a cable connection on the runway cable (Figure 16). __ **TAG:** Connect (5.5-ft) SCA cables to secondary leads of SCA and to the POWER INPUT connections on the strobe master (Figure 17). **NOTE:** There are different pin sizes on the secondary leads. Don't force that connection. __ **TAG:** After they have been laid, connect the strobe cables to the strobe master. **WARNING:** Be sure to connect the cables to the correct OUTPUT connectors.
CHECKLIST 6 continued on next page

CHECKLIST 6 - RUNWAY/MOS LIGHTING INSTALLATION
__ 9. Drive to position of outboard strobe slave unit while laying a 200-ft strobe cable along the extended runway/MOS centerline. __ Unload and position a strobe slave unit. Level unit and face window away from the runway/MOS. __ Install flash tube, if not done in step 8. __ Connect strobe cable to the connector marked SLAVE INPUT. **NOTE:** This also applies if using the spare strobe master as a slave.
__ 10. Return to strobe master location. Pick up tools used by the TAG and any extra materials and debris. Ensure there is slack in runway cable leading to the SCA. Leave a 10-ft runway cable segment if necessary.
__ 11. Drive to position of inboard strobe slave unit paying out runway cable along the extended runway/MOS centerline. __ Unload, position, and connect second strobe slave unit, as before. __ Install flash tube, if not done in step 8. __ Drop off 3 approach lights, 3 isolation transformers (45W), 3 stakes (if needed), and 2 (10-ft) runway cables for 1000-ft crossbar. __ Attach RAC containers (with edge/approach lights and isolation transformers) to trailer mounting pegs (2-person lift). Replace empty containers as required. __ **TAG:** At the inboard strobe location, position and connect the 3 crossbar approach lights (Figure 18). Space the lights 10 ft apart and 3 to 5 ft in front of the strobe cabinet.
__ 12. Drive toward threshold and place approach lights with 45W isolation transformers and stakes (if required) every 200 feet along extension of runway/MOS centerline while paying out runway cable. See Figure 6. __ **TAG:** Position each approach light along the extended centerline and connect it to the transformer and the transformer to the primary series circuit.
CHECKLIST 6 continued on next page

CHECKLIST 6 - RUNWAY/MOS LIGHTING INSTALLATION

__ 13. At threshold, place threshold/end lights, 100W isolation transformers (yellow tape on leads), 10-ft runway cables, and 2 ballast rings (or 1 stake) per fixture. Place outboard of threshold markers if they are in position. **NOTES:** Need one more light fixture than width of runway/ MOS divided by 10. Don't need a 10-ft cable between middle two lights in threshold bar. Place cables so male ends of connectors point in clockwise direction around runway/MOS.

__ **TAG:** Position lights no more than 10 ft from threshold and approximately 10 ft apart (Figure 5). Adjust spacing between light fixtures so outboard lights are in line with the edge lights. Face green side of lens out toward approach lights (red side in toward runway/MOS). Place isolation transformers inboard of lights. Connect 10-ft runway cables to isolation transformers and transformers to lights. Keep cable between transformer and light taught. Connect 200-ft runway cables to and from the approach lighting between the middle two lights on the threshold bar. Place ballast rings on fixture (or stake fixture).

__ 14. Drive along left side of runway/MOS paying out runway cable and placing an edge light with a 45W isolation transformer every 200 feet (Figure 4). Place inboard of orange edge markers, if they are in position. (Leave a stake or ballast ring at each light if lights to be held down.) **NOTE:** Don't place lights at taxiway intersections or in aircraft arresting system tape sweep areas (see Attachment 2).

__ **TAG:** Position lights no more than 10 ft from edge of runway/ MOS, and inboard of edge markers. Place isolation transformers outboard of lights. Connect runway cables to isolation transformers and transformers to lights. Keep cable between transformer and light taught. Stake fixture or place ballast rings as required.

__ 15. **TEAM A:** Stop at EDGE A PAPI location, and install PAPI system (Figure 7). See **CHECKLIST 7** for installation procedures. When complete, continue edge lighting installation and laying of the primary series circuit cable. **NOTE:** Ideally, PAPI location is pre-marked by others. Attachment 3 contains instructions for determining the correct distance from the threshold to the PAPI location.

CHECKLIST 6 continued on next page

CHECKLIST 6 - RUNWAY/MOS LIGHTING INSTALLATION
__ 16. Place DTG marker lights with 45W isolation transformers and 3 (50-ft) runway cables at 1000-foot markers (in the first 5,000 feet on the left side of the runway/MOS). See Figure 8. **NOTE for TEAM A:** Place the DTG marker lights only if the runway/MOS is to be set up for bi-directional operations. __ **TAG:** Position light to illuminate marker. Connect light to transformer and transformer to the runway circuit using 50-ft cables as needed.
__ 17. Place a marker light with 45W isolation transformer along with 2 or 3 (50-ft) runway cables outboard of any aircraft arresting system (Figure 8). **NOTES:** If necessary, use the light intended for the 5000-ft DTG marker. Lay runway cable (200-ft segments) outboard of the arresting system. **NOTE for TEAM A:** Place the arresting system marker light only if the runway/ MOS is to be set up for bi-directional operations. __ **TAG:** Position light to face marker. Connect light to transformer and transformer to the runway circuit. Use (50-ft) cables as needed. Reposition runway cable outboard of arresting system if not done when cable was laid.
__ 18. Continue placing lights and laying runway cable to opposite threshold. __ **TAG:** Continue positioning and connecting edge lights, DTG marker lights, and transformers until meeting up with TEAM A.
CHECKLIST 6 continued on next page

CHECKLIST 6 - RUNWAY/MOS LIGHTING INSTALLATION
__ 19. **TEAM A Only:** __ If the runway/MOS is to be set up for bi-directional operations, drive to the EDGE B PAPI location. Install second PAPI system following procedures in **CHECKLIST 7**. Return to END B threshold. __ Travel back along EDGE A connecting/positioning edge light fixtures, DTG marker lights, and isolation transformers until meeting TAG A. __ Drive to END A threshold and travel along EDGE B connecting and positioning edge light fixtures, DTG marker lights, and isolation transformers until meeting TAG B. __ Check with TEAM B to see if they need assistance. Park trailer #2 at predetermined location. __ If TEAM A is to install taxiway lighting, follow the procedures in **CHECKLIST 8**.
__ 20. **TEAM B Only:** __ Drive to predetermined location for regulator/control panel. __ Install the generator(s) and regulator/control panel following the procedures in **CHECKLIST 9**. **NOTE:** The primary regulator/control panel (trailer #1) is not normally set up until the taxiway lights, which are located in that trailer, are installed. __ Check with TEAM A to see if they need assistance. __ If TEAM B is to place the obstruction lights, follow the procedures in **CHECKLIST 8**.
__ 21. Reconnect the series circuit if left open for crater repair activities.

CHECKLIST 7 – PAPI INSTALLATION
__ 1. At PAPI location, unload 2 PAPIs, 1 SCA, 2 (50-ft) runway cables, 1 PAPI cable, 1 PAPI SCA cable (5.5 ft), photo cell, and 6 stakes. **NOTE:** Attachment 3 contains instructions for determining the correct distance from the threshold to the PAPI location.
__ 2. Get 2 ground rod segments (3 ft), 2 ground rod couplings, 1 ground clamp, 1 (25-ft) ground cable, and the ground rod driver.
__ 3. Get tools (screwdriver, adjustable wrench, and hammer)
__ 4. Connect the runway cables to the primary circuit along the runway/MOS edge and carry the loose ends to the inboard PAPI location.
__ 5. Remove 2 PAPI units from containers. Ensure the tilt switch cable is connected to the TILT SWITCH connector (Figure 19). Return containers to back of tow vehicle.
__ 6. Place inboard PAPI 50-60 feet from edge of runway/MOS. Place outboard PAPI 20-30 feet from inboard unit.
__ 7. Place SCA next to the inboard unit and connect the loose ends of the runway cables to the primary leads on the SCA (Figure 20).
__ 8. If possible, secure base of inboard PAPI. Remove PAPI from its base; level terrain under PAPI base, align PAPI base so it is parallel with runway/MOS centerline, then stake down. Put PAPI back on its base. **CAUTION:** Don't drive stakes all the way into the PAPI base. This can damage the base.
__ 9. Repeat for outboard PAPI. **WARNING:** If the elevation difference between the two units exceeds 12 inches, raise or lower the outboard unit or relocate both units to a more level location.
__ 10. Install photo cell, if needed (Figure 19).
__ 11. Drive ground rod at least 5 feet into the ground. Connect 25-ft ground cable to it and the other end of the cable to the ground lug on the SCA.
__ 12. Connect 5.5-ft SCA cable to J1 secondary lead on the SCA and to the POWER/CONTROL IN connector on the back panel of the inboard PAPI (Figure 21).
CHECKLIST 7 continued on next page

CHECKLIST 7 – PAPI INSTALLATION
__ 13. Connect the 30-ft PAPI cable to POWER/CONTROL OUT connector on the inboard PAPI and to the POWER/CONTROL IN connector on the outboard PAPI (Figure 21).
__ 14. Level and align the PAPI. __ Level the PAPI from side to side. Adjust front two knobs until bubble is centered. __ Get PAPI aiming device and set it to the specified approach slope/ aiming angle: 01-18 end _____ ° / 19-36 end _____ ° **WARNING:** Add 15 minutes (0.25°) to specified angle for inboard PAPI. Reduce angle by 15 minutes (0.25°) for outboard PAPI. __ Place aiming device on PAPI (tilt switch side) and turn rear adjusting knob until aiming device bubble is centered. Tighten the three securing knobs. Return aiming device to RAC. **NOTE:** Be sure you don't place the aiming device on a rivet on the PAPI cabinet. __ Loosen knob on tilt switch. Center the bubble and retighten knob (Figure 22).
__ 15. Pick up tools and any extra materials and debris.

CHECKLIST 8 – TAXIWAY/OBSTRUCTION LIGHTING INSTALLATION

__ 1. Connect trailer #1 to tow vehicle and trailer #4 behind trailer #1. **NOTE:** If the regulator/control panel on trailer #1 is already connected, either disconnect it or relocate needed taxiway lights and isolation transformers from it to the tow vehicle. Get ballast rings or stakes from trailers #2 or #3, and get extra cable protection strips from trailer #2.

__ 2. Drive to location on edge of runway/MOS where taxiway intersects.

__ 3. Place taxiway lights and isolation transformers in a gentle sweeping arc between the runway/MOS and the taxiway as shown in Figure 9.

- __ Place two lights at the beginning of the arc near the edge of the runway/MOS. These are the taxiway exit lights. The first light should be 2 ft outboard of the edge lights. Place the second light 5 ft outboard of the first on a line perpendicular to the edge of the runway/MOS.
- __ Space remaining lights 25 ft apart along the arcs and 50 ft apart in the straight sections of the taxiway. Place the lights within 10 ft of the edge of the taxiway.
- __ At the same time, lay (50-ft) runway cable segments between lights.
- __ Place two ballast rings or one stake at fixtures that can get hit by jet blast.
- __ At the taxiway fixture farthest from the runway, lay a (200-ft) runway cable across the taxiway. **NOTE:** You need the (200-ft) cable to avoid a cable connection in the middle of the taxiway. The connectors can't fit in the cable protection strip. **HINTS:** Delay laying this cable until the cable protection strip is in place. The cable will be too long, so spread out or coil the excess on one side.
- __ Continue placing fixtures, transformers, cables, and ballast rings/stakes on the other side to the taxiway exit light at the far taxiway/runway connection.

CHECKLIST 8 continued on next page

CHECKLIST 8 – TAXIWAY/OBSTRUCTION LIGHTING INSTALLATION
__ 4. Disconnect and remove the runway cable that crosses the taxiway at the edge of the runway/MOS, and tie the first taxiway light (taxiway exit light) into the primary series circuit. __ Disconnect the cable at the runway/MOS edge light (or a runway cable connection) closest to the taxiway exit light. Pull the two cables off opposite sides of the taxiway. __ Connect closest cable end to the taxiway exit light transformer. Use (50-ft) or (10-ft) cable segments, as needed, to make this connection. __ Connect the taxiway lights into the primary circuit on the opposite side after the last taxiway light and transformer are placed.
__ 5. Walk the taxiway circuit to connect lights, transformers, and cables. Position lights no more than 10 ft from edge of taxiway. Place isolation transformers outboard of lights. Keep cable between transformer and light fixture taught. Stake fixture or place ballast rings as required.
__ 6. Lay cable protection strip to protect the (200-ft) cable that crosses the taxiway. Mate cable protector sections and pin together. If possible, extend across and beyond the width of the taxiway (Figure 23). **CAUTION:** Be sure to pick up any loose cable protector pins to eliminate the FOD hazard. __ Insert cable into the slot. **HINT:** The easiest way to insert the cable is to hold the cable connector and press the end of the cable just behind the cable connector into the slot. Then using the connector and holding it to the slot, pull the cable through the slot to the opposite side (Figure 24). __ Secure the cable protection strip with sandbags on the ends.
__ 7. Install taxiway reflectors beyond the last light as needed. Install along the edge of the taxiway in line with the taxiway lights. Use the same spacing rules as for the lights.
__ 8. Repeat steps 2 through 7 for other taxiways.
__ 9. If towing trailer #1 and it is used as the regulator, return to the predetermined location for the regulator and reconnect it to the generator(s), control panel, and ground.
CHECKLIST 8 continued on next page

CHECKLIST 8 – TAXIWAY/OBSTRUCTION LIGHTING INSTALLATION
__ 10. **TEAM B:** Remove obstruction lights from container on trailer #1. Load into bed of vehicle. Install batteries. Survey MOS and taxiways for the 10 most prominent obstructions, and place lights there. Turn switch to ON. **NOTE:** Use rechargeable lead acid batteries if temperatures fall below zero degrees F. Otherwise, use the zinc-chloride batteries.

CHECKLIST 9 - REGULATOR/GENERATOR INSTALLATION
__ 1. Lay (200-ft) runway cable from the predetermined regulator location to the nearest cable connector on the edge of the runway/MOS. Open the series circuit at that cable connector. Connect the female end of the just laid cable to the male end of the open series circuit. Connect the male end of a second runway cable to the female end of the open series circuit, and lay a return cable back to the regulator. Park trailer #3. **NOTE:** Use the cable on trailer #4 if you need additional runway cable to complete the circuit.
__ 2. Move the regulator/control panel (trailer #1 or #4) to its predetermined operating location. __ Set all switches on the control panel to the OFF position. On the regulator panel, set the circuit breaker (CB1) to the off position (down) and turn the intensity selector switch (S1) to the OFF position. See Figures 25 and 26. __ Connect a (25-ft) ground cable to the grounding lug on the regulator trailer and a second (25-ft) cable to the lug on the control panel. See Figures 27 and 28.
__ 3. Establish common ground at regulator. __ Get 3 (3-ft) ground rod segments, 3 ground rod couplings, 4 ground clamps, and the ground rod driver. __ Drive ground rod 8 feet deep.
__ 4. Connect ground cables from regulator and control panel to common ground.
__ 5. Inspect and service generator per **CHECKLIST 2**, if not already done.
CHECKLIST 9 continued on next page

CHECKLIST 9 - REGULATOR/GENERATOR INSTALLATION

__ 6. Move generators (either or both trailers #5 and #6) into position and set them up.

If the generator is to be located greater than 20 ft from the regulator:

__ Tow generator and trailer #4 from the regulator to the generator site while paying out (250-ft) generator power cable segments from trailer #4. **NOTES:** The generator can be located up to 1000 ft from the regulator. When the distance is not too far, the team may choose to lay the generator power, control, and ground cables by hand.

__ Position generator. Park the generator on reasonably level ground. (The generator should be as level as possible during operation.) The unit should be well ventilated and within 25 ft of any auxiliary fuel supply. The soil should support the weight of the generator. The location should permit easy access for refueling the generator or the auxiliary fuel supply. For an indoor installation, follow the instructions in the technical order.

__ Connect pigtails on generator unit power cable to terminal board 2 (TB2). Use terminals L1-L3, L1-L2, or L2-L3 (Figure 29). **HINT:** The pigtails may be too short to use on terminals L1-L3 without stripping additional cable insulation. **CAUTION:** Do not use terminal L0—unless you intend to operate on 208 VAC. In that case, the generator must also be set up to deliver 208 VAC versus 416 VAC.

__ Connect the (250-ft) generator power cable to the generator unit power cable (Figure 30).

__ Connect the (250-ft) generator control cable to the connector on the blackout switch box (Figure 31). Then tow trailer #4 to the regulator while paying out the (250-ft) control cable segments.

__ Connect the (1000-ft) ground cable from the cable reel on trailer #4 to the common ground at the regulator. Then,

__ Tow trailer to the generator while paying out the 1000-ft ground cable. **NOTE:** If desired and situation warrants, can use 125-ft ground wires, cut wires from base stocks, or cut the 1000-ft wire.

__ Connect the (1000-ft) ground cable to the generator grounding terminal on TB2 (Figure 29).

__ Set up generator per **CHECKLIST 10**.

__ Return to regulator, and park trailer #4.

CHECKLIST 9 continued on next page

CHECKLIST 9 - REGULATOR/GENERATOR INSTALLATION
Step 6 continued: If the generator is to be located less than 20 ft from the regulator: __ Repeat the above steps but use the (25-ft) generator power, control, and ground cables and lay them by hand.
__ 7. Connect the generator power and control cables to the connectors at the side of the control panel (Figure 32). **CAUTION:** The control panel on trailer #1 has numbered connectors. Always connect the power and control cables from the same generator to the GENERATOR POWER IN and GENER-ATOR CONTROL connectors with the same numbers. __ Ensure the generator control switch (on the control panel) is in the OFF position. __ Connect the generator power cable to the connector on the control panel. __ Connect the (25-ft) generator control adapter cable to the last segment of the (250-ft) control cable. **NOTE:** This is necessary, because the connectors on the 250-ft control cable do not fit the connector on the control panel. __ Connect the control adapter cable to the connector on the side of the control panel.
__ 8. Connect the (6-ft) regulator control and power cables to the REG CONTROL and REG POWER connectors on the control panel and to the REMOTE CONTROL INPUT and the INPUT VOLTAGE connectors on the regulator (Figure 33).
__ 9. Perform functional check on the regulator and control panel using **CHECKLIST 11**.
__ 10. Connect the two leads of the runway cable (see step 1) to the OUTPUT CURRENT connectors on the regulator (Figure 34). **NOTE:** If the runway cable was laid correctly, the male/male runway cable adapter must be used to complete the connection.
__ 11. If used, set up auxiliary fuel supply within 25 ft of the generator and connect the fuel line to the generator. If required, place fuel spill containment around fuel supply. If desired, get a fire extinguisher.

CHECKLIST 10 – GENERATOR SET UP

__ 1. Safety steps:

__ At the regulator (trailer #1 or #4), be sure all switches on the EALS control panel are in the OFF position. On the regulator panel, set the circuit breaker (CB1) to the off position (down) and turn the intensity selector switch (S1) to the OFF position.

__ Be sure generator is grounded.

__ 2. Be sure the P11/J11 electrical connection is disconnected if auxiliary fuel is not used, and connected if it is. See Figure 35. This connection provides electrical power to the auxiliary fuel pump which fills the day tank on the generator. **CAUTION: If auxiliary fuel is <u>not used</u> and the P11/J11 connection is made, the auxiliary fuel pump can burn out**.

__ 3. Place DEAD CRANK switch in NORMAL position. See Figure 36.

__ 4. Ensure voltage reconnection terminal board (TB1) is positioned to 240/416V. See Figure 37.

__ 5. Set up the generator control panel. See Figure 38.

__ Push in DC CONTROL POWER circuit breaker (located on control bracket behind control panel - Figure 39).

__ Set FREQUENCY SELECT switch to 60Hz.

__ Set AM-VM transfer switch to match the pigtail connections on the generator output terminal board (TB2).

__ Place PARALLEL UNIT switch in UNIT position.

__ Set MASTER switch to PRIME AND RUN.

__ Push PRESS TO TEST button on malfunction indicator panel. [All lights should light up, and all lights should go out when released.]

__ Press BATTLE SHORT button to test light. [Indicator light should illuminate.]

__ Press AC CIRCUIT INTERRUPTER button to test light. [Indicator light should illuminate.]

CHECKLIST 10 continued on next page

CHECKLIST 10 – GENERATOR SET UP

__ 6. Start the generator. **CAUTION:** Don't crank engine longer than 15 seconds. Wait 15 seconds between attempts.

__ Rotate MASTER switch to start, and hold until engine starts, oil pressure reaches at least 25 psi, voltage has increased to near rated value, and engine has reached a stable operating speed. Release switch. **NOTE:** In cold weather, push ETHER switch to ON until engine speed stabilizes.

__ If using the auxiliary fuel source, rotate MASTER SWITCH to PRIME AND RUN AUX FUEL position.

__ Warm engine without load for 5 minutes (unless the situation requires immediate load).

__ Check COOLANT TEMP indicator for normal reading (170°-200°F). Repeat for OIL PRESSURE (25-60 psi).

__ Turn FREQUENCY adjust knob until FREQUENCY METER indicates 60 Hz.

__ Turn voltage adjustment potentiometer until the AC voltmeter (VOLTS AC) indicates 416 volts. Allowable range is 405 – 458 volts. **Compensate for voltage drop if generator is positioned away from regulator, as follows**:

IF CABLE LENGTH FROM REGULATOR IS	SET VOLTAGE AT
25 feet	416 volts
250 feet	425 volts
500 feet	434 volts
750 feet	441 volts
1,000 feet	450 volts

__ Press GROUND FAULT CIRCUIT INTERRUPTER TEST push button. Indicator window should be CLEAR. Press RESET button and ensure indicator is RED.

__ Place AC CIRCUIT INTERTRUPTER switch in CLOSED position.

__ Recheck voltage and frequency and adjust if required.

__ 7. Stop the generator.

__ Place AC CIRCUIT INTERRUPTER switch in OPEN position.

__ Allow generator to operate 5 minutes without load.

__ Place MASTER SWITCH in OFF position.

__ 8. Repeat steps 2-7 for second generator.

CHECKLIST 11 – REGULATOR/CONTROL PANEL FUNCTIONAL CHECK
__ 1. Ensure switches on the regulator panel are set as follows (see Figure 26): __ Intensity selector switch (S1) - REMOTE __ Master circuit breaker (CB1) - off (down position)
__ 2. Set switches on the control panel in the following positions (see Figure 25): __ GENERATOR CONTROL - OFF __ GEN1/GEN2 REMOTE START - OFF __ GENERATOR SELECTION - AUTO __ LIGHTING CONTROL - OFF __ STROBE CONTROL - OFF __ PANEL ILLUMINATION - can be in either ON or OFF position
__ 3. Connect male/male adapter cable to both OUTPUT CURRENT plugs on the regulator.
__ 4. Check automatic switching of generators on main control panel. __ Turn GENERATOR CONTROL switch ON. Determine which generator is to be the primary unit. __ Turn the REMOTE START switch for the primary unit to AUTO. [The primary unit should start up, and the RUN and ONLINE indicators for that generator should light up.] Wait 5 seconds, then: __ Turn the REMOTE START switch of the backup generator to AUTO. [Nothing should happen.] __ Turn the REMOTE START switch for the primary unit to OFF. [The primary unit should shut down. The backup generator should start up. The RUN and ONLINE indicators for the primary generator should go off and for the back up generator should light up.]
__ 5. Turn the circuit breaker (CB1) on the regulator panel to on (up) position. [The REGULATOR ON indicator light on the regulator panel should light up.]
CHECKLIST 11 continued on next page

CHECKLIST 11 – REGULATOR/CONTROL PANEL FUNCTIONAL CHECK
__ 6. Check lighting control from control panel. __ Turn LIGHTING CONTROL switch to LOW intensity. Pause while regulator performs internal checks. [Low intensity indicator should light up, and ammeter on regulator panel should show between 4.6 and 4.9 amps.] __ Turn LIGHTING CONTROL switch to MED intensity. [Ammeter should read between 5.3 and 5.7 amps for medium intensity setting.] __ Turn LIGHTING CONTROL switch to HIGH intensity. [Ammeter should read between 6.4 and 6.7 amps for high intensity setting.] __ Push SYSTEM BLACKOUT button. [The REGULATOR ON indicator light on the regulator panel should go out, and the ammeter reading should drop to zero.] Reset BLACKOUT RESET switch. __ Return LIGHTING CONTROL switch to OFF position, pausing at the LOW intensity setting while the regulator cycles.
___ 7. Check lighting control on regulator panel (Figure 40). __ Turn intensity selector switch (S1) from REMOTE to the low intensity (B1) setting. [Ammeter should show between 4.6 and 4.9 amps.] __ Turn intensity selector switch (S1) to the medium intensity (B2) setting. [Ammeter should read between 5.3 and 5.7 amps.] __ Turn intensity selector switch (S1) to the high intensity (B3) setting. [Ammeter should read between 6.4 and 6.7 amps.] __ Return intensity selector switch to OFF position, pausing at the B2 (medium) and the B1 (low) intensity settings while the regulator cycles.
CHECKLIST 11 continued on next page

CHECKLIST 11 – REGULATOR/CONTROL PANEL FUNCTIONAL CHECK
__ 8. Perform regulator open-circuit test. __ Turn the circuit breaker (CB1) on the regulator panel to off (down) position. __ Remove male/male adapter cable from OUTPUT CURRENT plugs on the regulator. __ Turn the circuit breaker (CB1) to on (up) position. __ Turn intensity selector switch (S1) to B1 (low) intensity setting. [The regulator should deenergize in less than 2 seconds, and the OPEN CIRCUIT and OUTPUT VOLTAGE LIMIT indicator lights on the regulator panel should light up.] **WARNING: Immediately turn intensity selector switch (S1) to off if open circuit protective device does not activate within 2 seconds.** __ Turn intensity selector switch (S1) to OFF position. [The open circuit protective device should reset.] __ Repeat above two steps to ensure protective device resets. __ Turn intensity selector switch (S1) to OFF position and main circuit breaker (CB1) to off (down) position. __ Return intensity selector switch (S1) to REMOTE position.
__ 9. Turn REMOTE START and GENERATOR CONTROL switches on control panel to OFF position. [Generator will shut down.]

CHECKLIST 12 – ACTIVATING THE EALS FROM TRAILER #1

__ 1. Set switches on the regulator panel as follows (see Figure 26):
- __ Intensity selector switch (S1) - REMOTE
- __ Master circuit breaker (CB1) - off (down position)

__ 2. Set switches on control panel as follows (see Figure 25):
- __ GENERATOR CONTROL - OFF
- __ GEN1/GEN2 REMOTE START - OFF
- __ GENERATOR SELECTION - AUTO
- __ LIGHTING CONTROL - OFF
- __ STROBE CONTROL - OFF
- __ PANEL ILLUMINATION - can be in either ON or OFF position

__ 3. Turn GENERATOR CONTROL switch ON. Determine which generator is to be the primary unit.

__ 4. Turn the REMOTE START switch of the primary unit to AUTO. [The RUN and ONLINE indicators should light up.] Wait 5 seconds, then:

__ 5. Turn the REMOTE START switch of the backup generator to AUTO.

__ 6. Turn the circuit breaker (CB1) on the regulator panel to ON.

__ 7. Set LIGHTING CONTROL to proper intensity. Intensity indicator should light up. Adjust as necessary based on pilot requests. Without other input, use these visibility conditions to determine proper intensity.

VISIBILITY CONDITION	INTENSITY SETTING
Night over 4 miles	Low
Night 3 to 4 miles	Medium
Night under 3 miles	High

__ 8. Set STROBE CONTROL to proper end ___ 1 – 18 or ___ 19 - 36

CHECKLIST 13 – ACTIVATING THE EALS FROM TRAILER #4
__ 1. Set switches on the regulator panel as follows (see Figure 41): __ Intensity selector switch (S1) - REMOTE __ Master circuit breaker (CB1) - off (down position)
__ 2. Set switches on control panel as follows (see Figure 41): __ GENERATOR CONTROL - OFF __ LIGHTING CONTROL - OFF __ STROBE CONTROL - OFF __ PANEL ILLUMINATION - can be in either ON or OFF position
__ 3. Turn GENERATOR CONTROL switch ON. (The ONLINE indicator should light up.) Wait 5 seconds, then:
__ 4. Turn the circuit breaker (CB1) on the regulator panel to ON.
__ 5. Set LIGHTING CONTROL to proper intensity. Intensity indicator should light up. Adjust as necessary based on pilot requests. Without other input, use these visibility conditions to determine proper intensity. VISIBILITY CONDITION — INTENSITY SETTING Night over 4 miles — Low Night 3 to 4 miles — Medium Night under 3 miles — High
__ 6. Set STROBE CONTROL to proper end ___ 1 – 18 or ___ 19 - 36

CHECKLIST 14 – MANUAL LOAD TRANSFER AT THE PRIMARY CONTROL PANEL (FROM GENERATOR 1 TO GENERATOR 2*)
__ 1. Turn generator 2 on by turning the GEN 2 REMOTE START switch from AUTO to ON. [The GEN 2 RUN indicator should light.]
__ 2. Turn GENERATOR SELECTION switch from AUTO to GEN 2. [The GEN 2 ONLINE indicator should light and the GEN 1 ONLINE and GEN 1 RUN indicators should go out.]
__ 3. To reestablish automatic transfer capability, turn GENERATOR SELECTION switch and the GEN 2 REMOTE START switch back to the AUTO position.
* To transfer from GEN 2 to GEN 1, use these instructions but substitute GEN 1 for GEN 2 and vice versa.

CHECKLIST 15 – SYSTEM BLACKOUT AT CONTROL PANEL.
__ 1. Press SYSTEM BLACKOUT button.
__ 2. To resume operation, rotate BLACKOUT RESET switch to RESET and release. See Figure 25.

CHECKLIST 16 – NORMAL SHUTDOWN PROCEDURES
__ 1. Turn LIGHTING CONTROL switch on control panel to OFF position.
__ 2. At regulator panel, turn circuit breaker (CB1) to off (down) position and intensity selector switch (S1) to OFF position .
__ 3. Let generator run 3 minutes.
__ 4. Turn generator off by turning REMOTE START switches on main control panel to OFF position. (Step not done on backup control panel.)
__ 5. Turn GENERATOR CONTROL switch on control panel to OFF position.

CHECKLIST 17 – EMERGENCY SHUTDOWN PROCEDURES
Use any one of the following procedures.
__ 1. At control panel: __ Turn GENERATOR CONTROL switch to OFF position. [Kills generators and all power to the system.] Or, __ Press SYSTEM BLACKOUT button. [Kills lights. Generators still run.] Or,
__ 2. At regulator panel: __ Turn regulator circuit breaker (CB1) off (down position). [Kills all power to the regulator and lighting circuit.] Or, __ Turn intensity selector switch (S1) to OFF. [Kills lights. Generators still run.] Or,
__ 3. At the generator: __ Press the EMERGENCY STOP button. [Kills generator and all power to the system.]

CHECKLIST 18 – POST INSTALLATION ACTIONS
__ 1. Gather empty containers in one location. Consider reloading and re-securing to the trailers. **NOTE:** Be sure containers are dry before closing for storage.
__ 2. Fold and store tarps for the regulator and generator trailers in use.
__ 3. Move remaining trailers to designated parking locations, close RAC doors, and place tarps back on trailers. **NOTE:** Dry wet tarps before folding and storing or before placing on trailers.
__ 4. Periodically check all lights and strobes to ensure they are operating. This includes obstruction lights. Also check: __ Angle on DTG marker lights __ Alignment of edge lights and threshold lights __ Cables clear of aircraft movement __ PAPI settings __ Approach lights and strobes aligned with runway/MOS centerline __ Taxiway entrance sweeps __ Ground connections
__ 5. Check light fixtures subject to jet blast to see if they need additional ballast rings or must be staked down.
__ 6. Revet regulator/control panel and generators if site is subject to attack. Protect backup regulator.
__ 7. Mark location of cable, if it is placed in grass that will be cut. Periodically make sure the markers are visible.
__ 8. Check on cable protection strips for alignment, movement, buckling, damage, and cable pulling out of the slot. Check sandbags. Replace damaged or deteriorating bags.

CHECKLIST 19 – ISOLATING AN OPEN-CIRCUIT IN THE SERIES CIRCUIT
__ 1. Turn power off. Visually check series circuit for open conditions. If open is found, reconnect connectors or replace faulty cable or transformers. Re-energize the circuit to see if the lights work.
__ 2. If open is not visible, sectionalize the circuit. __ For safety, disconnect homerun cables from regulator output terminals. __ Disconnect the series cable at light fixtures on opposite sides of the runway/MOS, pull the ends to the "middle" of the runway/MOS, and reconnect the cables to complete a smaller primary circuit. (Can also use a spare runway cable segment to connect the cables on opposite sides of the runway/MOS to close the circuit.) __ Reconnect the homerun cables at the regulator and energize to test the smaller circuit. If the segment lights up, the open is in the portion of the circuit omitted from the test. If the segment does not light, the open is in the tested segment.
__ 3. Continue segmenting the faulty portion of the circuit, and repeat the test on ever-smaller segments until the open is found.
4. Replace faulty component and retest.

CHECKLIST 20 – FINDING A SHORT-TO-GROUND IN THE SERIES CIRCUIT
__ 1. Energize circuit to highest intensity setting. Note first and last light that are dimmed.
__ 2. Inspect for evidence of cable or transformer damage in the circuit between the "normal" and the "dimmed" light fixture.
__ 3. Deenergize circuit and replace faulty cable segments or transformers. Reenergize to test the fix.

CHECKLIST 21 – ON-EQUIPMENT TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
Complete loss of lighting	Operator error	At the primary control panel: 1. Verify that either GEN 1 ONLINE or GEN 2 ONLINE indicator light is illuminated. (At the backup panel, the single ONLINE light should be illuminated.) 2. Verify that the LIGHTING CONTROL switch is set on LOW, MED, or HIGH. 3. Verify that the system is not "blacked out" by using the BLACKOUT RESET switch.
	No power to regulator	If ONLINE indicator light not illuminated, try bringing one generator online manually. Then try other generator.
	Neither generator working properly	Refer to generator TO.
	Regulator improperly set	At the regulator: Set intensity selector switch (S1) to the REMOTE position. Ensure circuit breaker (CB1) is ON (up position).
	Control panel not working	Check if system operates using the regulator intensity selector switch (S1).
	Regulator does not turn on using intensity selector switch (S1)	Check input voltage to S1 switch. If voltage present, regulator is bad. Use backup regulator/control panel, or replace or repair regulator. If voltage not present, check cable connections. If cables OK, control panel is bad. Use backup regulator/control panel, or replace or repair control panel.
CHECKLIST 21 continued on next page		

CHECKLIST 21 – ON-EQUIPMENT TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
	Regulator turns on using intensity selector switch (S1) but does not operate remotely from the control panel	1. Make sure regulator and control panel are properly grounded. 2. Using true-RMS reading voltmeter, check for proper signal input (see system TO). If signal is bad, check connections. If connections are OK, control panel is bad. Use backup regulator/control panel, or replace or repair control panel. 3. If signal is good, regulator is bad. Use backup regulator/control panel, or replace or repair regulator.
Complete loss of lighting (continued)	Regulator shut down from open-circuit protection (Open-circuit red LED would be illuminated)	If open-circuit LED (red) is illuminated: 1. Check for proper regulator operation. (See system TO.) 2. If regulator does not work, use backup regulator/control panel or replace or repair regulator. 3. If regulator does work, find and fix open circuit in lighting loop. See **CHECKLIST 19**.
	Regulator shut down from overcurrent protection (Overcurrent red LED would be illuminated).	If overcurrent LED (red) is illuminated, regulator is bad. Use backup regulator/control panel, or replace or repair regulator.
	Regulator repeatedly causes circuit breaker CB1 to trip	Regulator is bad. Use backup regulator/control panel, or replace or repair regulator.
Loss of greater than 20% of the edge, approach, or threshold/end lights.	Lamp failures	Replace all failed light fixtures. If there are not enough spare light fixtures, relamp failed fixtures.
CHECKLIST 21 continued on next page		

CHECKLIST 21 – ON-EQUIPMENT TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
Loss of PAPI unit	PAPI unit misalignment	Check that unit is properly aimed.
	Lamp failure	Replace lamp.
	Series circuit adapter failure	Disconnect series circuit adapter from PAPI unit. Check output voltage of series circuit adapter using a true RMS reading voltmeter. If no voltage is present and runway circuit operates properly, change series circuit adapter.
	PAPI unit failure.	If PAPI unit is properly aligned with a good lamp and power adapter is functioning properly, replace PAPI unit.
Complete loss of strobe segment.	Strobe control transmitter or receiver failure	At the EALS control panel, check operation of strobe selector switch. 1. If both strobe segments repeatedly fail to operate, replace control panel. 2. If one strobe segment operates and one fails, check control timing sequence for failed segment. If incorrect, replace control panel.
	Improper generator frequency	At the generator control panel check the frequency. If other than 60 Hz, adjust using the manual speed control.
	Strobe segment series circuit adapter failure	Disconnect series circuit adapter from strobe control unit. Check output voltage of series circuit adapter using a true-RMS reading voltmeter. If not between 228 VAC and 264 VAC and runway circuit operates properly, change series circuit adapter.
	Strobe master unit failure	Replace strobe master unit.
Loss of strobe units but not entire segment.	Strobe control unit trigger failure	Check that all of the trigger LEDs on the strobe control board are illuminating in sequence. If not, replace the strobe master unit or replace the strobe control board in the unit.

CHECKLIST 21 continued on next page

CHECKLIST 21 – ON-EQUIPMENT TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
	Interlock switch failure	Check for proper operation of interlock switches on failed strobe slave unit. There should be continuity through the switches when they are fully depressed and fully extended. There should be no continuity when they are in the middle "normal" position. If this is not the case, replace the replace strobe slave unit or replace the switches.
	Loose cable connections	Tighten cables.
	Failed flash tube	Replace flash tube.
	Failed strobe slave unit	Replace strobe slave unit.
Portion of runway circuit dimming	Multiple shorts to ground	Find and repair runway circuit. See **CHECKLIST 20**.

CHECKLIST 22 – STROBE SLAVE UNIT TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
Strobe slave unit does not operate and trigger relay does not trigger	Improper input voltage or faulty connections	See system TO.
	Failed interlock switches	See system TO.
	Faulty trigger relay	See system TO.
Strobe slave unit does not operate but trigger relay does trigger	Flasher unit on/off switch (S104) is in the off position	Move on/off switch to the on position.
	Failed flash tube	Replace flash tube.
	Blown fuse F101 or F102	Check and replace blown fuses.
	Faulty trigger relay	See system TO.
	Fuses F101 or F102 blow repeatedly due to faulty components	Visually inspect components and wiring for signs of damage or loose connections. If no evidence is found, see system TO.
Strobe slave unit operates but skips	Faulty flash tube	Replace flash tube.
	Faulty trigger relay	See system TO.

CHECKLIST 23 – STROBE MASTER UNIT TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
Strobe master unit does not operate when turned on locally	Improper input voltage or loose connections	See system TO.
	Blown fuses	Check fuses F101 and F102. Replace if blown.
	Faulty interlock switches	See system TO.
	Faulty power relay	See system TO.
	Faulty control board	See system TO.
Strobe master unit operates but does not send power and control signals to all strobe slave units	Loose connections	Check for loose connections.
	Failed trigger output	See system TO.
Strobe master unit operates locally but is not controlled properly remotely	Incorrect strobe segment setting	Ensure that the LOCAL-REMOTE-OFF switch is in the remote position and that the strobe segment selector switch is set properly.
	Faulty strobe control signals transmitted by the EALS control panel	See system TO.
	Faulty strobe control board	See system TO.

CHECKLIST 24 – PAPI TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
All lights out	Wiring disconnected	Check to make sure all connections are tight and wiring is in good condition.
	Unit out of alignment	Realign unit.
	Loss of input power	Check for proper input power.
	Circuit malfunction	Troubleshoot circuit. See **CHECKLISTs 19 and 20**.
	Failed time delay or K1 relay	See system TO.
Lamp does not operate	Lamp burned out	Replace lamp.
Lights do not brighten during daytime	Failed photo cell	Replace photo cell.
	Failed K2 relay	See system TO.

CHECKLIST 25 – CONTROL PANEL TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
Failure to provide power to regulator	Loose regulator power input/output connection	Check/reconnect cable assembly connection.
Failure to control runway lights	Blown fuses	Check and replace fuses.
	Loose regulator control output connection	Check/reconnect cable assembly connection.
	Switch failure, wiring fault, or faulty or loose other components	See system TO.
Failure to provide proper control of strobe segments	Strobe control transmitter failure	See system TO.
Indicator or panel lamp light not working	Faulty lamp or wiring.	See system TO.

CHECKLIST 26 – REGULATOR TROUBLESHOOTING		
TROUBLE	POSSIBLE CAUSE	REMEDY
Regulator does not turn on using intensity selector switch (S1)	Fuse F1 blown	Check and replace fuses F1 if faulty.
	Faulty component	See system TO.
Regulator does not turn on using remote control but operates using local intensity selector switch (S1)	Improper input signal	See system TO.
	Blown fuses	Check and replace if necessary fuse F4 (on Control PCB) with new ¼-amp slow-blow fuse. Check and replace if necessary fuse F5 (on panel) with new ¼-amp slow-blow fuse.
	Faulty Control PCB	See system TO.
Regulator repeatedly causes circuit breaker (CB1) to trip	Faulty feedback transformer T2/main transformer T1	See system TO.
	SCR1 or Control PCB is faulty	See system TO.
Regulator shuts down from overcurrent protection (red LED lit)	Improper calibration	See system TO.
	SCR1 or Control PCB is faulty	See system TO.
Regulator shuts down from open-circuit protection (red LED lit)	Regulator output is open-circuited	See system TO.
	Contactor K1 is faulty	See system TO.
	Faulty Control PCB	See system TO.
Incorrect output current	Improper calibration	See system TO.
	Faulty Control PCB	See system TO.

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ATTACHMENT 1
LOCATION OF EQUIPMENT ON TRAILERS

TRAILER NO. 1

STORAGE POSITION ON TRAILER	CONTENTS OF CONTAINER
Under Trailer Storage (UTS) Compartment	250 - taxiway reflector bases
Random Access Container (RAC)	40 - taxiway lights 4 - edge/approach lights 1 - threshold/end light 53 - isolation transformers (45W) 250 - taxiway reflector tops 1 - PAPI aiming device 1 - PAPI photocell 1 - strobe SCA cable 1 - PAPI SCA cable 1 - regulator power cable 1 - regulator control cable 1 - male/male runway cable adapter 1 - female/female runway cable adapter 1 - generator unit power cable 10 - ground rod couplings 5 - ground rod clamps spare component parts (see list in this attachment)
1 strobe master container	1 - strobe master unit
1 PAPI container	1 - PAPI unit
	10 - obstruction lights (with batteries) 23 - spare batteries
Primary control panel	
Regulator	

TRAILER NO. 2

STORAGE POSITION ON TRAILER	CONTENTS OF CONTAINER OR REEL
UTS	1 - series circuit adapter 13 - cable protector segments 48 - ballast rings 250 - stakes 1 - technical order (TO 35F5-3-17-1)
RAC	56 - edge/approach lights 16 - threshold/end lights 5 - DTG marker lights 55 - isolation transformers (45W) 17 - isolation transformers (100W) 1 - PAPI aiming device 1 - PAPI photocell 3 - strobe flashtubes 2 - strobe SCA cables 1 - PAPI SCA cable 1 - regulator power cable 1 - regulator control cable 2 - male/male runway cable adapters 1 - female/female runway cable adapter 10 - ground rod couplings 5 - ground rod clamps
1 strobe master unit container	1 - strobe master unit
2 PAPI containers	1 - PAPI unit
Cable reel	65 - 200' runway circuit cable segments 20 - 50' runway circuit cables 2 - 200' strobe cables 2 - 125' ground cables 1 - PAPI cable

TRAILER NO. 3

STORAGE POSITION ON TRAILER	CONTENTS OF CONTAINER OR REEL
UTS	1 - strobe series circuit adapter 144 - ballast rings 230 - stakes 1 - technical order (TO 35F5-3-17-1)
RAC	56 - edge/approach lights 16 - threshold/end lights 5 - DTG marker lights 55 - isolation transformers (45W) 16 - isolation transformers (100W) 1 - PAPI aiming device 1 - PAPI photocell 3 - strobe flashtubes 2 - strobe SCA cables 1 - PAPI SCA cable 1 - regulator power cable 1 - regulator control cable 2 - male/male runway cable adapters 1 - female/female runway cable adapter 10 - ground rod couplings 5 - ground rod clamps
1 strobe master unit container	1 - strobe master unit
2 PAPI containers	1 - PAPI unit
Cable reel	65 - 200' runway circuit cable segments 20 - 50' runway circuit cables 2 - 200' strobe cables 2 - 125' ground cables 1 - PAPI cable

TRAILER NO. 4

STORAGE POSITION ON TRAILER	CONTENTS OF CONTAINER OR REEL
UTS	52 - cable protector segments 1 - tool box
4 strobe slave unit containers	1 - strobe slave unit in each container
Cable reel	7 - 200' runway circuit cable segments 45 - 50' runway circuit cables 39 - 10' runway circuit cables 4 - 250' generator power cables 1 - 25' generator power cable 4 - 250' generator control cables 2 - 25' generator control adapter cables 1 - 1000' ground cable 5 - 25' ground cable 1 - 200' strobe cable 1 - PAPI cable
Backup control panel	
Regulator	
Spare tire storage box	1 - spare tire 3 - ground rod driving rods 3 - ground rod drivers 20 - ground rod sections 1 - lug wrench 1 - jack 1 - jack handle

TRAILER NO. 5

STORAGE POSITION ON TRAILER	CONTENTS OF CONTAINER
UTS	2 – series circuit adapter
MEP-805 Generator with remote start kit	
Blackout switch	
Generator unit power cable	
Remote start cable	

TRAILER NO. 6

STORAGE POSITION ON TRAILER	CONTENTS OF CONTAINER
UTS	1 – series circuit adapter 1 – tool box
MEP-805 Generator with remote start kit	
Blackout switch	
Generator unit power cable	
Remote start cable	

SPARE PARTS IN TRAILER NO. 1

COMPONENTS	SPARE PART
Edge/approach light	8 – 45W lamps 2 – clear lens
Threshold/end light	5 – 120W lamps 1 – split red/green lens
Taxiway light	6 – 30W lamps 1 – blue lens
Approach strobes	2 – Flash tubes 5 – fuses (5A) 5 – fuses (0.25A)
PAPI	2 – 200W lamps
Regulator	5 – fuses (2A)
Control panels	5 – fuses (1/4A) 5 – fuses (1A, 250V) 5 – fuses (1A, 500V)
Runway circuit cable	5 – plugs 10 – receptacles
Distance-To-Go (DTG) marker light	1 – 45W, PAR 38 lamps

ATTACHMENT 2
TAPE SWEEP CLEAR ZONES

The easiest way to determine the tape sweep area for an aircraft arresting system (AAS) is to pull the tape to its full extension. Remove all light fixtures and isolation transformers that the tape would hit, and reposition the runway cable out of this area. Repeat this process in the opposite direction if the aircraft arresting system will be used in both directions.

You can also place a person or an easily visible object at the location on the runway/MOS centerline where the arresting system tape would be at its full extension. That distance is usually 990 feet, but the system can be set up for a 1,200-foot tape run out. A person standing at the arresting system or at the 990-foot (1,200-foot) position can direct another person to remove lights and move cable that are located inside of the line of sight between the arresting system and the person/object at the centerline.

For a 990-foot tape, the tape sweep area/light free zone can extend anywhere form 0 to 700 feet from the aircraft arresting system. The distance depends on the runway/MOS width, the pendant length of the arresting system, and the distance that the edge lights and isolation transformers are set back from the edge of the runway/MOS. The length of the light free zone increases as the runway/MOS width decreases, as the pendant get longer, and as the set-back distance gets smaller. Table 3 shows the approximate light free zone distances for an aircraft arresting system set for a 990-foot tape payout, for both 90- and 153-foot pendants, and for edge light offset 0, 5, and 10 feet.

Table 3. Light Free Zone Distances.

MOS WIDTH (in feet)	PENDANT LENGTH (in feet)	EDGE LIGHT OFFSET		
		0 FEET	5 FEET	10 FEET
		Distance from AAS to far edge of tape sweep area (in feet)*		
50	90	550	450	350
50	153	700	650	600
90	90	150	50	0
90	153	450	400	350
150	153**	50	0	0

* The distances listed in the table are rounded up to the nearest 50-foot. For any other conditions, you must interpolate this data.

** There are no numbers for a 90-foot pendant on a 150-foot wide runway, because the 90-foot pendant effectively reduces the runway width to 90 feet.

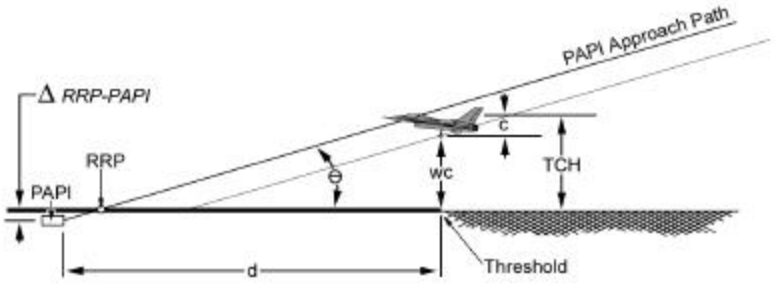
ATTACHMENT 3
LOCATING THE PAPI LIGHTS

Basics. The proper location of the PAPI system is important. The PAPI projects light beams that provide a visual approach path that guides the pilot to the intended touchdown zone on the runway.

When on path, the pilot will see red on the inboard unit and white on the outboard unit. The pilot will see red on both units if too low, and white if too high.

The goal in locating the PAPI is to create the touchdown zone as close to the threshold as possible to maximize the runway length available for rollout and yet ensure a margin of safety against an aircraft that lands too low.

The following diagram shows the features that must be considered when determining the location of the PAPI lights.



θ - angle of approach path (PAPI aiming angle)
RRP - runway reference point
d - distance from threshold to location of PAPI
TCH - threshold crossing height
wc - wheel clearance over threshold
c - cockpit-to-wheel height
Dthreshold-RRP - elevation difference between the threshold and the runway reference point (RRP) at the centerline of the runway/MOS.
DRRP-PAPI - elevation difference between the RRP (crown of the runway/MOS) and beam centers of the PAPI lights.

Angle of Visual Approach Path. The PAPIs are set up so the pilot will land in the first few hundred feet of the runway. The angle of the approach path is normally between 2.5° and 4.0°, with 3.0° being the standard. The approach angle may be greater than 4.0° to accommodate local conditions.

Runway Reference Point. The RRP is the point on the runway/MOS centerline where the visual glide path intersects the runway/MOS.

Minimum Wheel Clearance Over Threshold. While the usable pavement begins at the threshold, we don't want the pilot landing at or before the threshold if the aircraft comes in too low. To reduce the chance of this hap-

pening, the PAPI must be located far enough away from the threshold so the wheels of the landing aircraft are at least 30 feet above the threshold.

Threshold Crossing Height. However, since the pilot's eyes—not the wheels—are on the visual approach path, we must add the height of the pilot above the wheels to the 30-foot wheel clearance height. That combined height is called the threshold crossing height (TCH). Obviously the height of the pilot above the wheels, known as the cockpit-to-wheel height, varies for each aircraft. Rather than be concerned with each aircraft that uses a runway, aircraft are placed in one of four height groups, and the height group dictates the threshold crossing height. Table 4 shows the height groups with their corresponding cockpit-to-wheel heights and minimum threshold crossing heights. When determining the location of the PAPI, use the height group TCH for the largest aircraft that routinely uses the runway.

Table 4. Visual Threshold Crossing Height Groups.

HEIGHT GROUP	APPROXIMATE COCKPIT-TO-WHEEL HEIGHT	THRESHOLD CROSSING HEIGHT (TCH)
#1 T-37, T-38, C-21, T-1, C-12, C-20, & fighter jets	10 ft (3m) or less	40 ft (10 m)
#2 F-28, CV-340/440/580, B-737, DC-9, DC-8, C-9, T-43, C-130, B-2	15 ft (4.5 m)	45 ft (12 m)
#3 B-727/707/720/757, KC-135, C-141, C-17, B-52	20 ft (6 m)	50 ft (15 m)
#4 B-747/767, L-1011, DC-10, A300, KC-10, C-5, VC-25	Over 25 ft (7.5 m)	75 ft (22 m)

Elevation Differences. The difference in elevation between the threshold and the beam center of the PAPI lights also affects the location of the PAPI. When the beam center is lower than the threshold, the PAPI units must be moved farther away from the threshold. In the not-too-common situation where the beam centers are higher than the threshold, we must move the

PAPI units closer to the threshold. Typically we break this elevation difference into two components.

First we determine the elevation difference between the threshold and the runway reference point. In peacetime, this difference is established by surveyors. In an emergency, a person can estimate the difference from a topographic map or can make a visual estimate—a guess.

Second we determine the elevation difference between the runway reference point and the beam centers of the PAPI lights. In peacetime, the beam centers should be installed within 12 inches of the RRP elevation. In that case, the elevation difference is ignored (treated as zero). For an emergency installation, a person should visually estimate this elevation difference.

Calculating the PAPI Location. Determining the threshold to PAPI distance is a matter of simple geometry. The distance is shown by this equation:

$$d = (TCH + D_{threshold\text{-}RRP} + D_{RRP\text{-}PAPI}) (1/\tan \theta)$$

Get the TCH from Table 4. Add (or subtract) the elevation differences to the TCH. Then multiply that sum by the value of 1 divided by the tangent of the approach angle. Table 5 gives the 1/tan θ values for the normal range of approach angles.

Table 5. Value of 1/tan q.

APPROACH SLOPE ANGLE	1/TAN q
2.50°	23
3.00°	19
3.50°	16.3
4.00°	14.3

Example Calculations. These examples show how the different factors influence the location of the PAPI.

Example 1. Conditions: The largest aircraft using the runway/MOS is a C-17 which is in height group #3, consequently the TCH is 50 feet. The threshold elevation is 3 feet higher than the RRP, and the PAPI lights are within 12 inches of the RRP. The approach angle is 3°, so 1/tan 3° is 19. Consequently, the calculated threshold to PAPI distance is:

d = (50 ft + 3 ft + 0 ft) (19) = 1,007 feet (round up to 1010 feet)

NOTE: In this example, the PAPI and distance-to-go markers would be located in essentially the same place. Consequently, the distance-to-go marker and light would have to be moved at least 50 feet away from the PAPI.

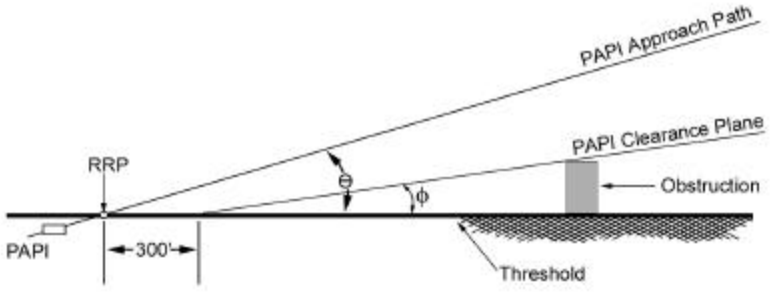
Example 2. Conditions: The largest aircraft is a C-17. The threshold elevation is 3 feet lower than the RRP, and the approach angle is 4°. Consequently, the calculated threshold to PAPI distance is:

d = (50 ft - 3 ft + 0 ft) (14.3) = 672 feet (round down to 670 feet)

PAPI Clearance Plane. For normal conditions, the PAPI must also be located so that no obstructions penetrate the PAPI clearance plane. That plane begins at a point 300 feet downwind (closer to the threshold) from the RRP. The aiming angle for the PAPI glide path shall be not less than 1.2° above the PAPI clearance plane. The following diagram shows these details.

Common obstructions include tall buildings, trees, towers, and hills and mountains. Obstructions into the PAPI clearance plane will not be a problem when using the previously established approach angle for an existing runway.

When required, establish a PAPI clearance plane following the instructions in AFMAN 32-1187(I). This should be done by the CE Engineering technicians with support from the Airfield Management people.



θ - angle of approach path (PAPI aiming angle)
ϕ - angle of PAPI clearance plane (at least 1.2° less than θ)

PAPI Location for an Emergency Installation. For an emergency installation of the EALS, the proper location of the PAPI system should be marked by others. If not, estimate the elevation differences and make quick calculations as described above.

An alternative approach is to set the PAPI units 950 feet from the threshold and adjust their location to account for the elevation difference between the lights and the RRP. This approach assumes no elevation difference between the threshold and the RRP.

NOTE: The EALS technical order uses a 950-foot threshold to PAPI distance. That is the optimum distance for a 50-ft TCH, a 3° approach angle, and no elevation difference between the threshold and the beam center of the PAPI lights.

Table 6 gives the distance the PAPI must be moved away from the threshold to account for the elevation difference between the RRP and the PAPI lights when the PAPIs cannot be installed within 12 inches of the RRP elevation.

Table 6. Crown Height Elevation Adjustment.

ELEVATION DIFFERENCE IN FEET (CROWN HIGHER THAN PAPI)	DISPLACEMENT DISTANCE IN FEET AWAY FROM THE THRESHOLD*
1	20
2	40
3	60
4	75
5	100
8	150
10	200
* Based on 3° approach angle, which yields a 1/tan θ value of 19. This table rounds that value to 20.	

Sources of Information. The information for this attachment comes from AFMAN 32-1187(I), *Design Standards for Visual Air Navigation Facilities* and FAA Advisory Circular 150/5345-28, PRECISION APPROACH PATH INDICATOR (PAPI) SYSTEMS.

ATTACHMENT 4
SUPPORTING GRAPHICS

Figure 2. Terms Relating to the Runway/MOS.

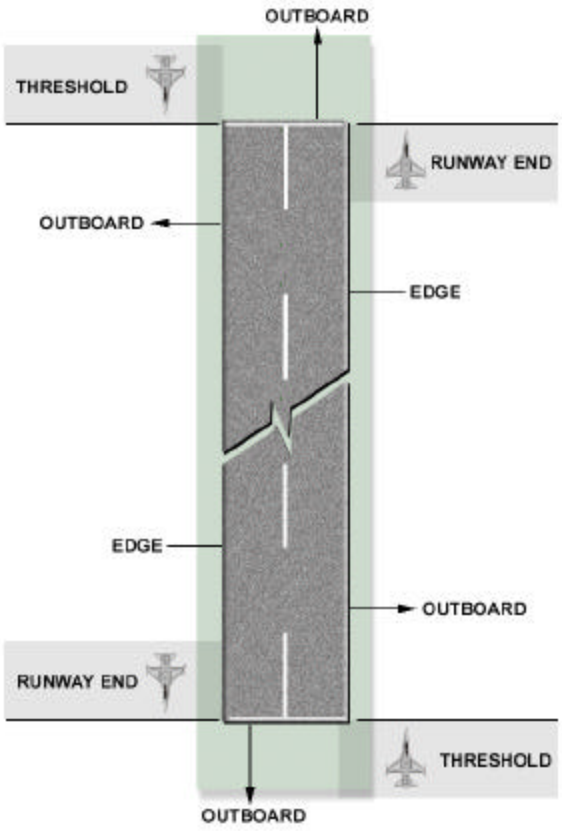


Figure 3. Runway/MOS Orientation and Designation.

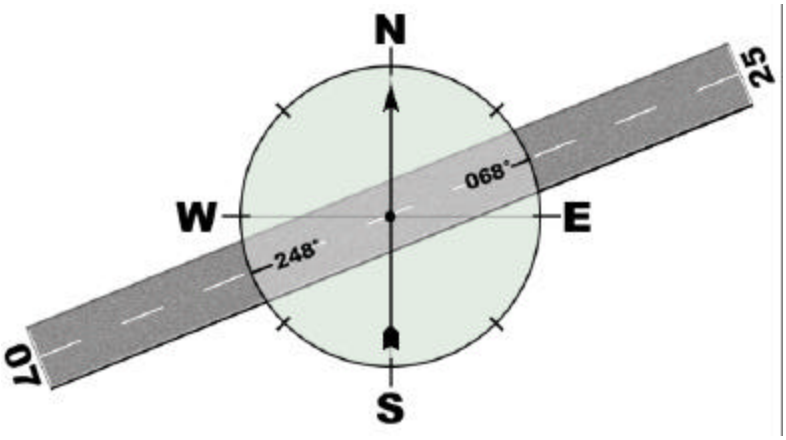


Figure 4. Edge Light Placement.

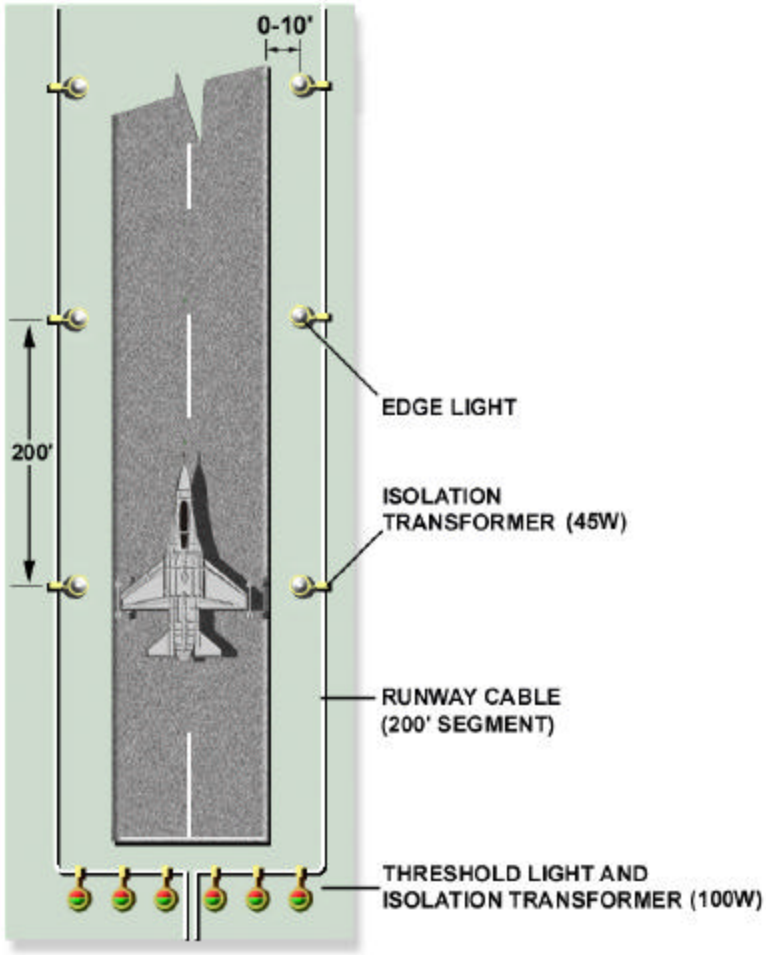


Figure 5. Threshold Light Placement.

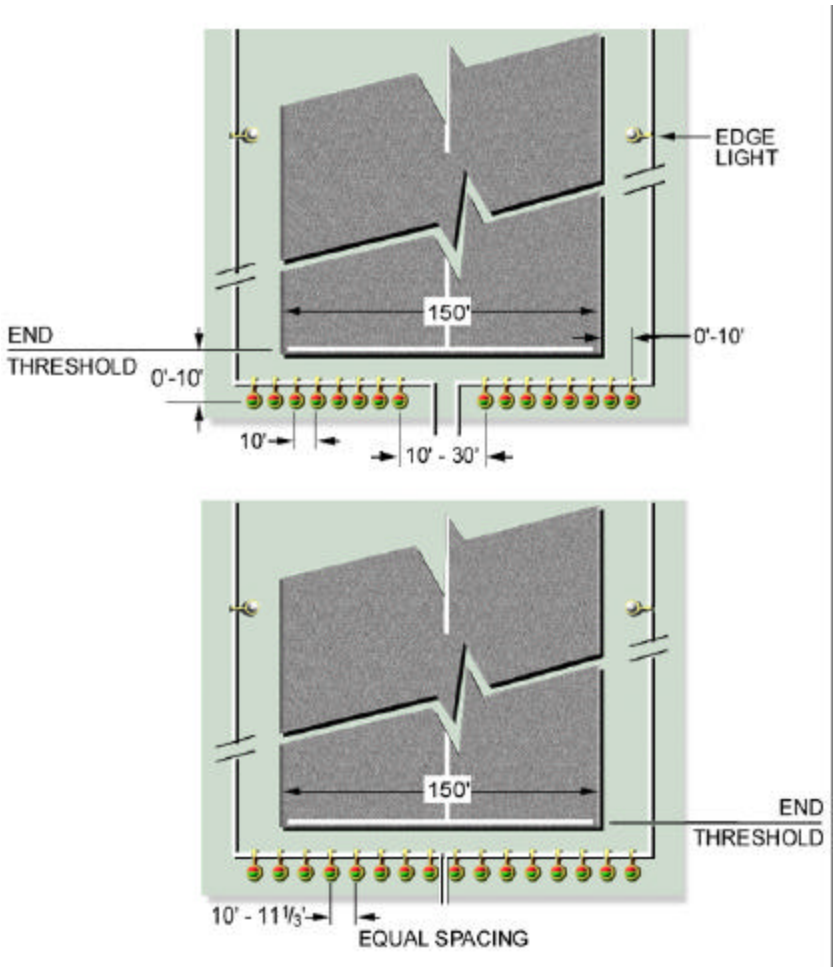


Figure 6. Approach and Strobe Light Placement.

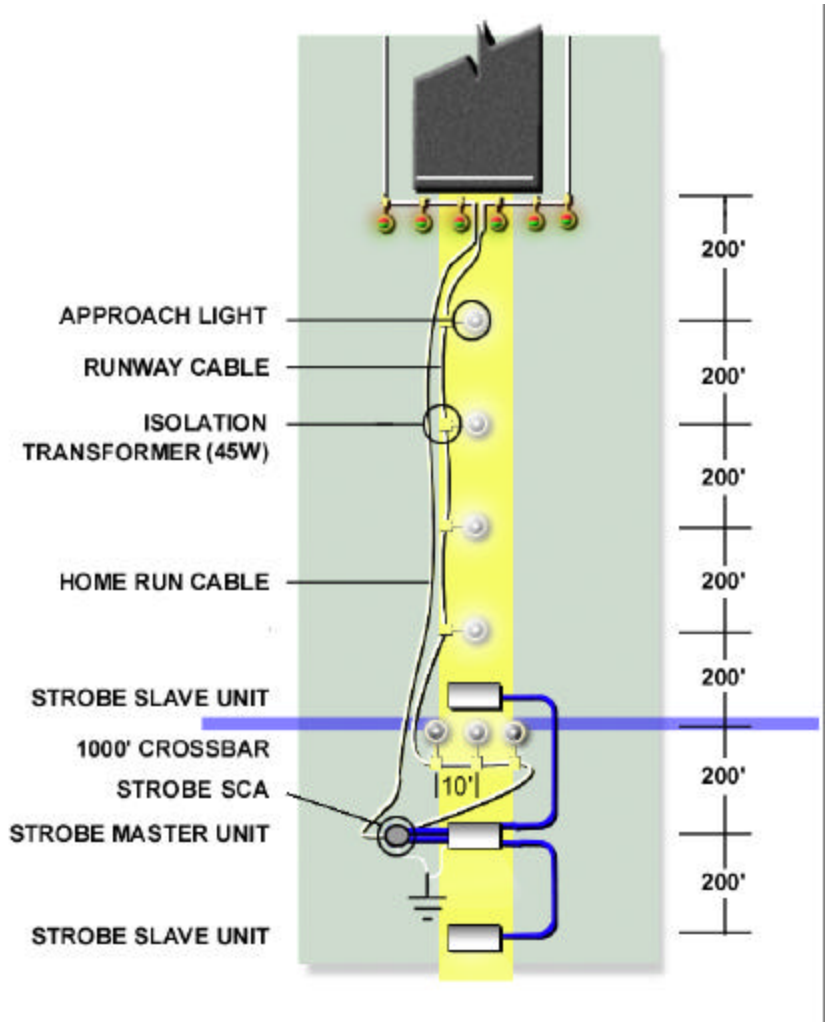


Figure 7. PAPI Light Placement.

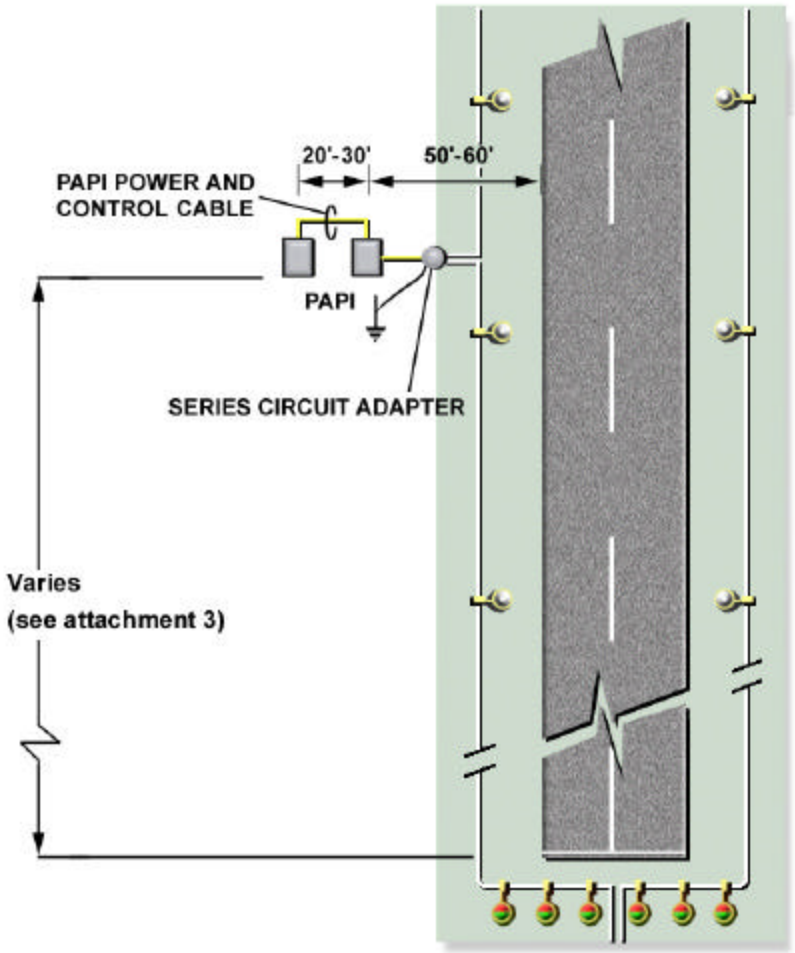


Figure 8. Distance-to-Go Marker Light Placement.

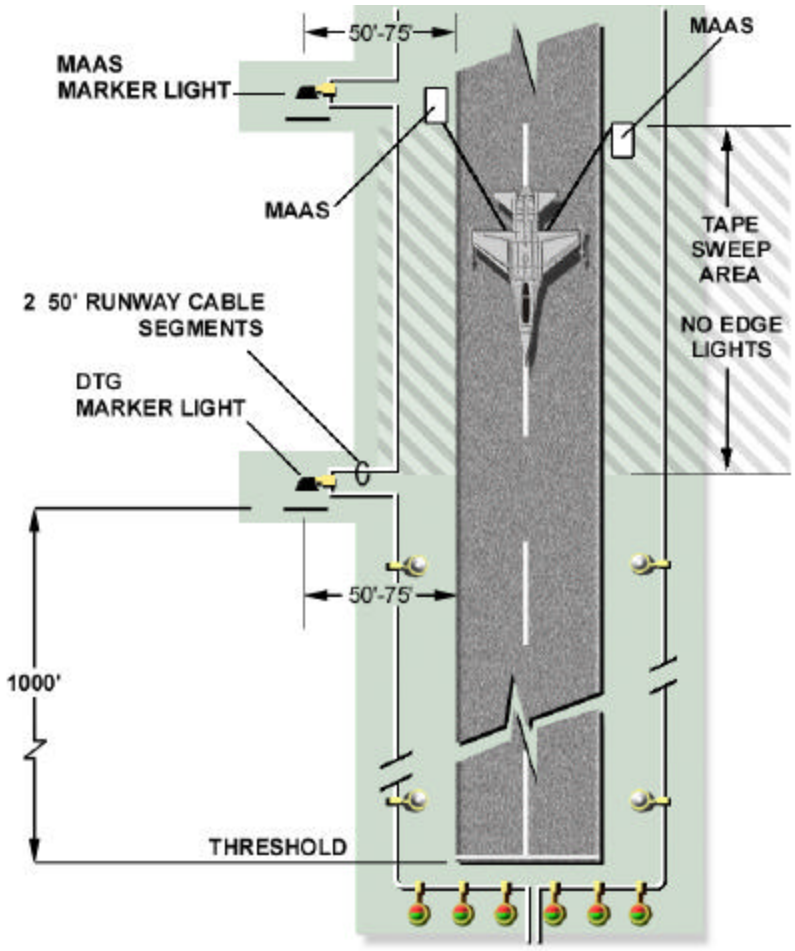


Figure 9. Taxiway Light Placement.

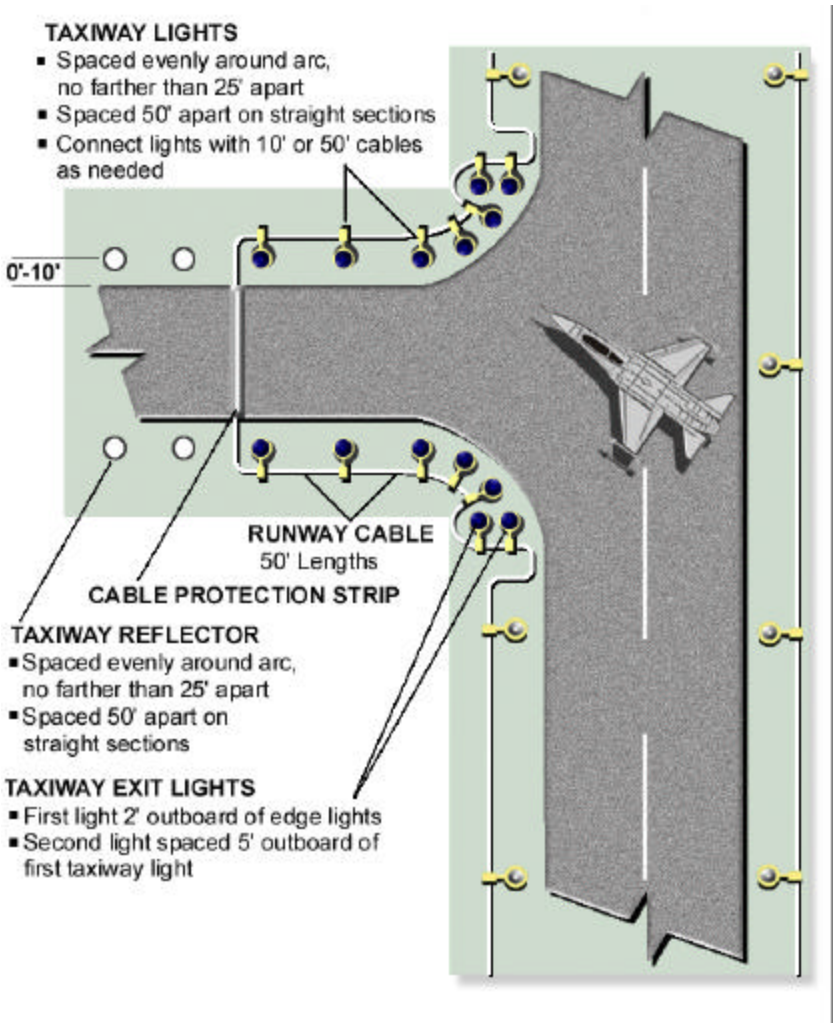


Figure 10. Generator and Regulator Placement.

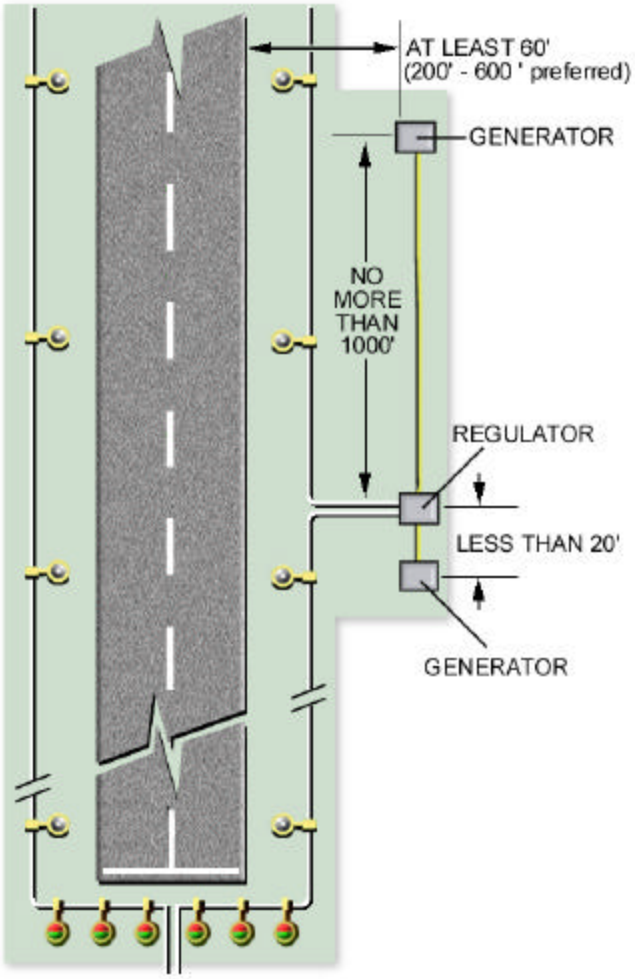


Figure 11. Female Connector—Inside Plug Out of Position.

Figure 12. Cable Rewind Instructions on Cable Reel.

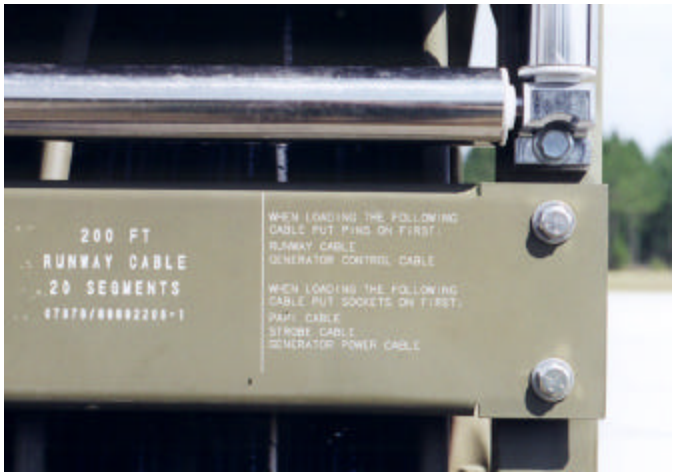


Figure 13. Shorting Capacitors.

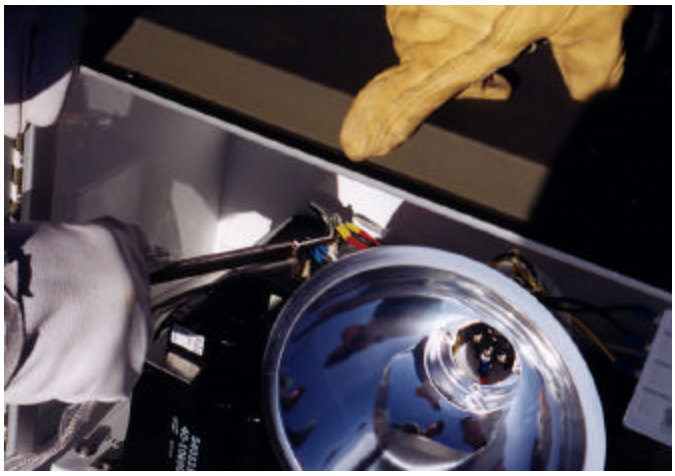


Figure 14. Strobe Unit ON-OFF Switch.

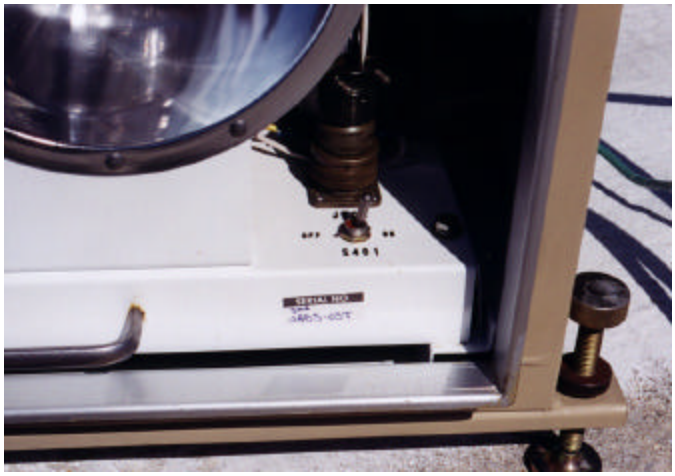


Figure 15. Remote-OFF-ON (S301) Switch.

Figure 16. Strobe Master with Series Circuit Adapter.

Figure 17. Cable Connections at Strobe Master.

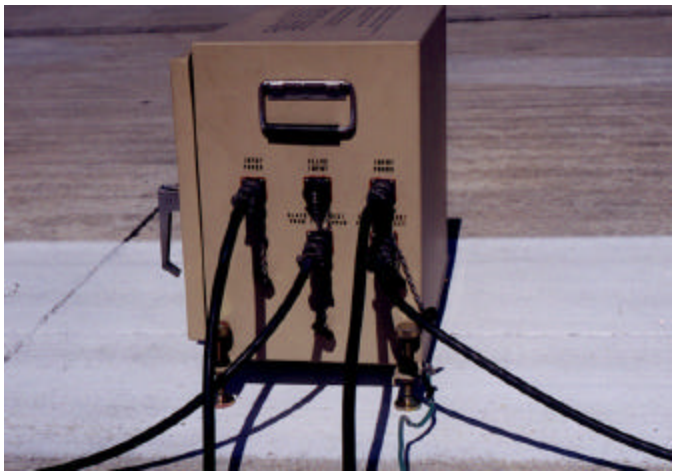


Figure 18. Approach Cross Bar.

Figure 19. Tilt Switch and Photo Cell Connections.

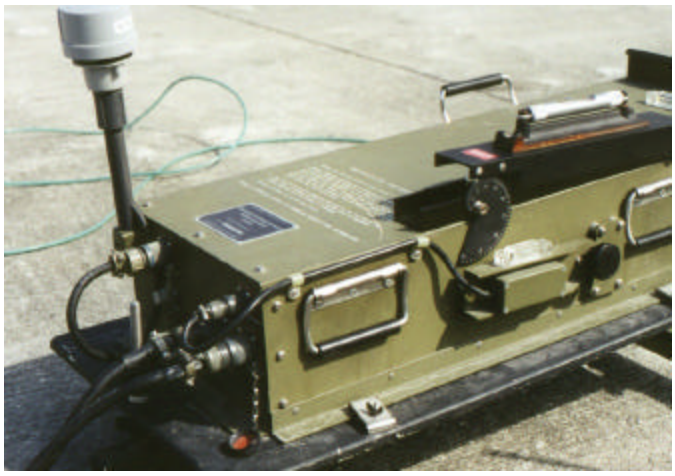


Figure 20. Inboard PAPI and Series Circuit Adapter.

Figure 21. Back Side of Inboard PAPI.

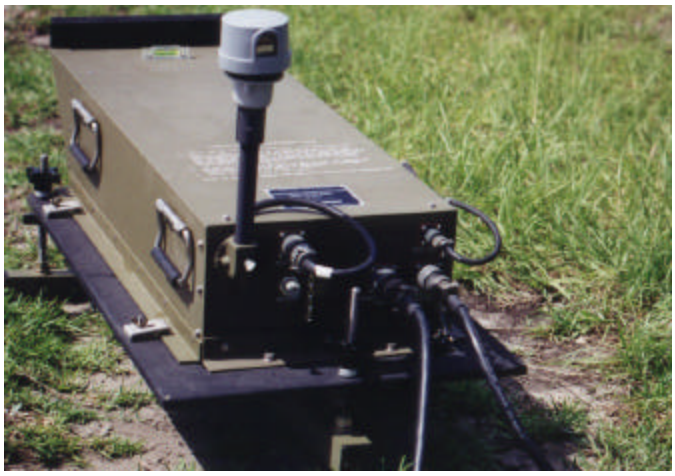


Figure 22. PAPI Alignment.

Figure 23. Installing Cable Protection Strips.

Figure 24. Laying Cable in Cable Protection Strips.

Figure 25. Primary Control Panel (Trailer #1).

Figure 26. Backup Control Panel (Trailer #4).

Figure 27. Regulator Ground.

Figure 28. Control Panel Ground.

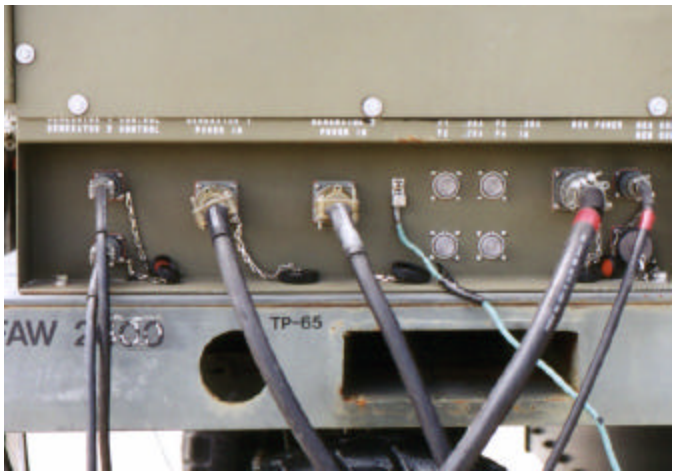


Figure 29. Generator Unit Power Cable Connection to Generator.

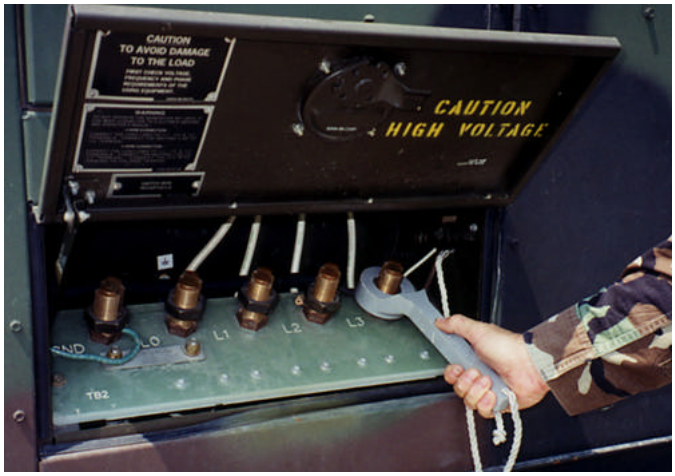


Figure 30. Generator Power and Unit Power Cable Connections.

Figure 31. Generator Control Cable Connection to Generator.

Figure 32. Cable Connections at Control Panel.

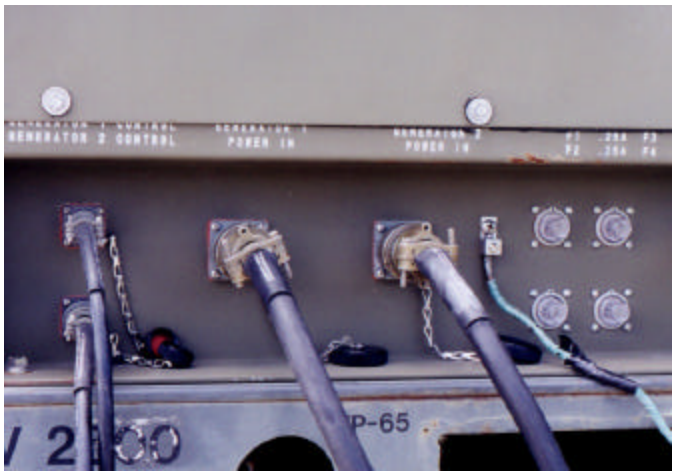


Figure 33. Cable Connections from Control Panel to Regulator.

Figure 34. Output Current Connectors on Regulator.

Figure 35. P11/J11 Connection on Generator.

Figure 36. Dead Crank Switch.

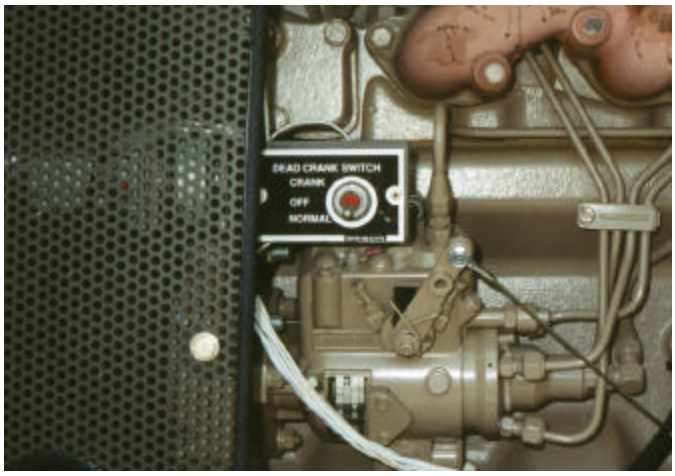


Figure 37. Generator Terminal Board #1 (TB1).

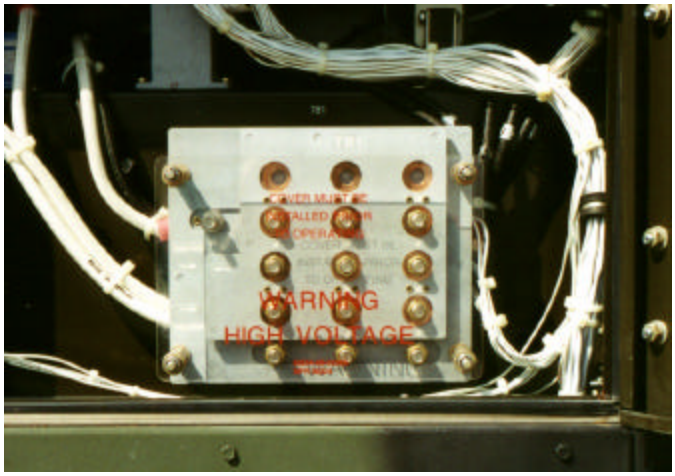


Figure 38. Generator Control Panel.

Figure 39. Control Bracket Behind Generator Control Panel.

Figure 40. Regulator Control Panel.

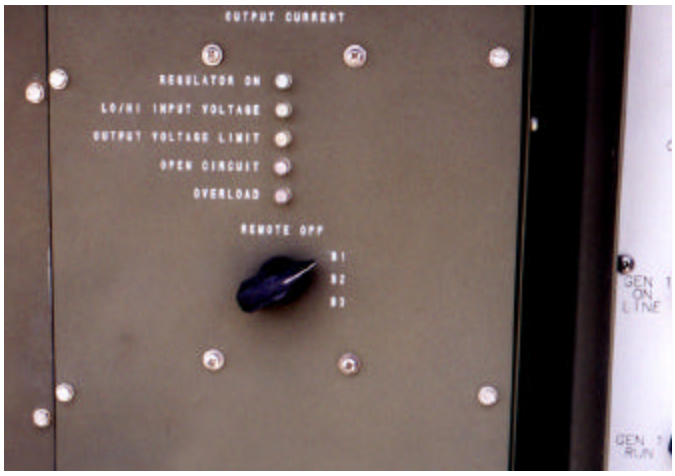


Figure 41. Backup Control Panel and Regulator Panel.